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ENVIRONMENTAL CHEMISTRY
AND APPLIED SCIENCE
June/July 2018
Time: 3 Hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN ENVIRONMENTAL SCIENCE AND TECHNOLOGY

MODULE I

ENVIRONMENTAL CHEMISTRY AND APPLIED SCIENCE

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** the questions in this section.*

1. Describe with the aid of equations the chemical pathway for fixation of atmospheric nitrogen in the soil. (4 marks)

2. List **four** natural ways of reducing the concentration of pollutants in a large water mass. (4 marks)

3. Iron in 3.819 g of a soil sample was estimated by isolation with solvent extraction, followed by titration with 0.02147 M EDTA of which 36.28 cm^3 was required. Determine the concentration of the iron in the soil sample in ppm, (Fe = 56). (4 marks)

4. (a) Give the IUPAC name of the following organic molecules:

   (i) $CH_2F = CH_2F$; (1 mark)

   (ii) $CH_3 - CH_2 - CH = CH - \underset{\displaystyle Cl}{\underset{|}{CH}} - CH_3$. (1 mark)

   (b) Complete the following chemical reactions:

   (i) $CH_3CH = CH_2 + HF \longrightarrow$ (1 mark)

   (ii) $H_2N - NH_2 + O_2 \longrightarrow$ (1 mark)

5. Determine the value of x in the following equations:

   (a) $\frac{8 \times 2^x}{4^3} = 16$. (2 marks)

   (b) $4x^2 + 3x - 9 = 0$. (2 marks)

6. Determine the integrals of the following functions:

   (a) $\int_0^1 4x^3 + 3x^3 + 1$; (2 marks)

   (b) $\int_0^{\pi} \cos x$. (2 marks)

7. Find the value of x, y and z for simultaneous equations:

$$2x + 7y + 5z = 50$$
$$4x - 3y + z = 40$$
$$3x - 7y - 8z = -55$$

(4 marks)

8. (a) State Newton's first law of motion. (2 marks)

(b) An object of mass 20 kg which was initially at rest was released from 80 m above the earth's surface. Ignoring air resistance, determine the velocity at which it strikes the ground, (take g = 10 m/s^2). (2 marks)

9. (a) State Hooke's law. (1 mark)

(b) A wire of length 20 m and diameter 0.02 mm extended by 0.8 mm when a weight of 100 N was applied. Determine Young's modulus of the wire. (3 marks)

10. Describe how the fixed points of a mercury thermometer of the range 0 °C to 100 °C are established. (4 marks)

SECTION B (60 marks)

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

11. (a) State the **five** postulates of the kinetic theory of gases. (5 marks)

(b) Determine the value of the universal gas constant R in SI units using ideal gas equation, (1 atm = 101325 Pa). (5 marks)

(c) Derive the equation $PV = \frac{1}{3}Nm\overline{c^2}$. (10 marks)

12. (a) Define the following terms as used in dynamics:

(i) momentum; (2 marks)

(ii) elastic collision. (2 marks)

(b) (i) State Newton's second law of motion. (2 marks)

(ii) Two cars of mass 400 kg and 500 kg were moving in the same direction at velocities of 72 m/s and 27 m/s respectively. The cars collided and stuck together in an elastic collision. Calculate the final velocity of the embedded cars. (8 marks)

(c) (i) Define 'centre of mass of an object'. (2 marks)

(ii) A 2 kg particle is at a distance of 4 m from a 3 kg particle. Locate the centre of mass of this system. (4 marks)

13. (a) Determine the derivatives of the following functions from first principles:

(i) $y = x^3 + 4x + 1$; (5 marks)

(ii) $y = \sin x$. (10 marks)

(b) A rectangular plot contaminated with radioactive waste was fenced with an electric wire of length 100 m. The plot has a concrete wall on one side such that only three sides of the plot were fenced. Determine the maximum area of the plot. (5 marks)

14. (a) Describe the significance of the following in water:

(i) Biological oxygen demand (BOD); (5 marks)

(ii) Chemical oxygen demand (COD). (5 marks)

(b) The following procedure was used in an experiment to determine the COD of 100 cm^3 of a portable water sample. Silver nitrate was added followed by 4 M H_2SO_4. After boiling, a 25 cm^3 aliquot was mixed with excess of 0.2 M $K_2Cr_2O_7$. The excess $K_2Cr_2O_7$ was back-titrated with acidified 5.7 cm^3 of 0.02 M Fe^{2+}. Determine the COD of the water sample in ppm. (10 marks)

15. (a) Differentiate between macro-nutrients and micro-nutrients as used in soil chemistry giving **two** examples of each. (8 marks)

(b) The following procedure was followed in an experiment to determine phosphorus in a 4.875 g soil sample. The solid sample was ground to fine paste and dried in an oven at 110 °C for 2 hours and cooled in a desiccator until room temperature. The dry sample was mixed with excess H_2O_2 and shaken with constant stirring until effervescence stopped. The phosphorus was converted into $(NH_4)_3PO_4$ through a chemical process. The $(NH_4)_4PO_4$ was reacted with excess concentrated NaOH and the ammonia produced was distilled into 100 cm^3 of 1.0 M HCl.

$$(NH_4)_3PO_{4(aq)} + 3NaOH_{(aq)} \longrightarrow Na_3PO_{4(aq)} + 3H_2O_{(l)} + 3NH_{3(g)}$$

The excess HCl was back-titrated with 8.3 cm^3 of 0.05 M NaOH.

(i) Determine the amount of phosphorous in the sample in ppm Po_4^{3-}. (10 marks)
$(Po_4^{3-} = 95)$.

(ii) Explain why the sample was mixed with H_2O_2. (2 marks)

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