FORM TP 2009156

TEST CODE 02112020

MAY/JUNE 2009

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

CHEMISTRY

UNIT 1 – PAPER 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of SIX **compulsory** questions in TWO sections.
2. Section A consists of THREE structured questions, ONE from each Module. Section B consists of THREE extended response questions, ONE from each Module.
3. For Section A, write your answers in the spaces provided in this booklet. For Section B, write your answers in the separate answer booklet provided.
4. ALL working MUST be shown.
5. The use of non-programmable calculators is permitted.
6. A data booklet is provided.

SECTION A

Answer ALL questions in this section.

Write your answers in the spaces provided in this booklet.

MODULE 1

FUNDAMENTALS IN CHEMISTRY

1. (a) Each element has a characteristic 'fingerprint' line emission spectrum. Niels Bohr, in 1913, proposed an explanation for the emission spectrum of the elements.

(i) State the property of elements which is responsible for the characteristic line spectrum of each element.

_____

[1 mark]

(ii) Sketch a diagram of the line emission spectrum of hydrogen. On your diagram, indicate the direction of **increasing** frequency and **increasing** wavelength.

[3 marks]

(iii) Explain, in terms of electronic transitions, the origin of the lines in the Balmer series.

_____

_____

_____

_____

_____

_____

[4 marks]

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(iv) State the region of the electromagnetic spectrum in which the lines in the Balmer series occur.

_____

[1 mark]

(v) Calculate the energy (E) of a quantum of radiation with a corresponding frequency (ν) of 4.57×10^{14} Hz. ($h = 4 \times 10^{-13}$ kJ s mol^{-1})

_____

_____

_____

_____

_____

[2 marks]

(b) Figure 1 represents the apparatus assembled by a student for the experimental determination of the heat of combustion of ethanol.

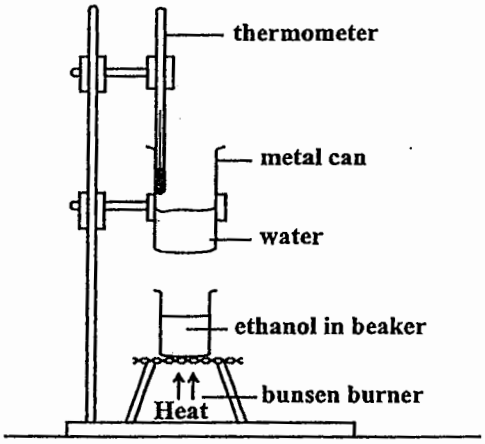

Figure 1. Student's apparatus for determination of heat of combustion of ethanol

Identify FOUR errors in the assembly of the apparatus in Figure 1.

_____

_____

_____

_____

[4 marks]

Total 15 marks

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MODULE 2

KINETICS AND EQUILIBRIA

2. (a) State TWO factors which affect reaction rates.

_____

_____

[2 marks]

(b) The data in Table 1 were obtained for the decomposition of nitrogen dioxide at 673 K.

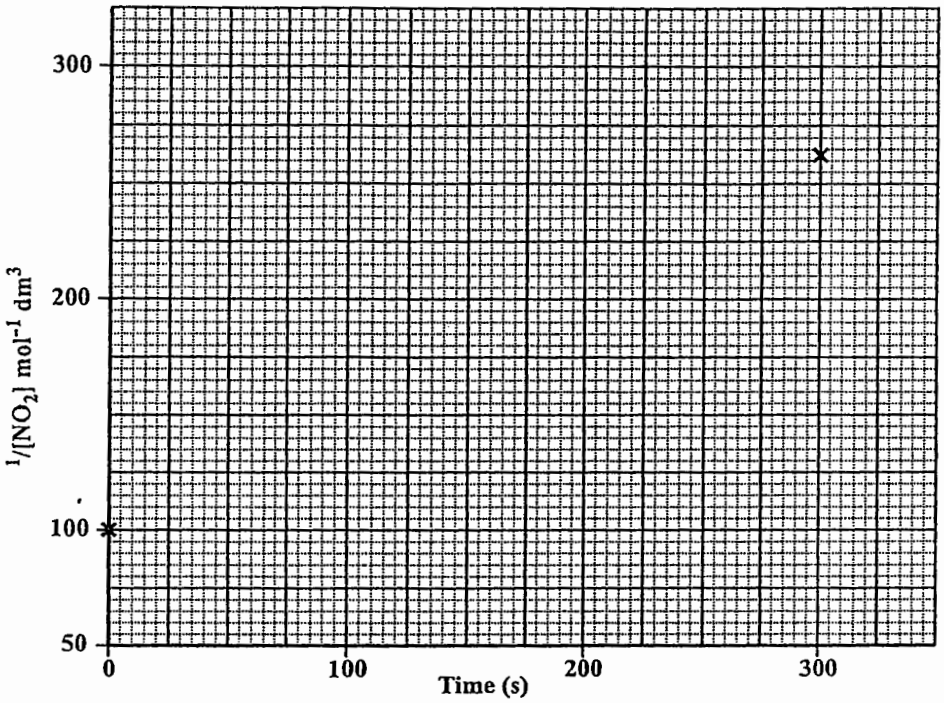
$$NO_2(g) \rightarrow NO(g) + \tfrac{1}{2} O_2(g)$$

TABLE 1 : DECOMPOSITION OF NITROGEN DIOXIDE

Time (s)	$[NO_2]$ mol dm^{-3}	$\frac{1}{[NO_2]}$ mol^{-1} dm^3
0.0	0.0100	100
50.0	0.00787	_____
100.0	0.00649	154
200.0	0.00481	_____
300.0	0.00380	263

(i) Complete Table 1 by writing the missing values for $\frac{1}{[NO_2]}$. [2 marks]

(ii) Plot a graph of $\frac{1}{[NO_2]}$ against time, on the grid below. The first and last points have been plotted on the grid.



[2 marks]

(iii) From your graph, determine the order of the reaction with respect to NO_2. Give a reason for your answer.

Order of reaction:

_____

Reason:

_____

[2 marks]

(iv) State the rate law for the reaction.

_____

[1 mark]

(v) Use the slope of the graph to determine the value and units of the rate constant, k, for the reaction.

_____

[2 marks]

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(c) Several experimental methods, including titrimetry, can be used to determine reaction rates. Suggest TWO OTHER methods which can be used to determine reaction rates.

_____

_____

[2 marks]

(d) Outline TWO experimental steps in the determination of the reaction rate of an esterification reaction using titrimetry.

_____

_____

_____

_____

[2 marks]

Total 15 marks

MODULE 3

CHEMISTRY OF THE ELEMENTS

3. (a) Insert arrows in the relevant boxes in Figure 2 to show the electronic configuration of the species. **[5 marks]**

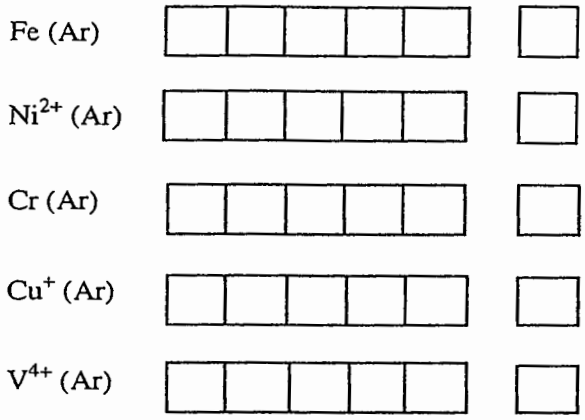

Figure 2. Electronic configuration of different species

(b) Use the distribution in the d-orbitals to account for colour in transition metal ions.

_____

_____

_____

_____

[2 marks]

(c) Account for the observation that Zn^{2+} compounds are normally colourless.

_____

_____

_____

[2 marks]

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(d) Figure 3 refers to the following reaction scheme.

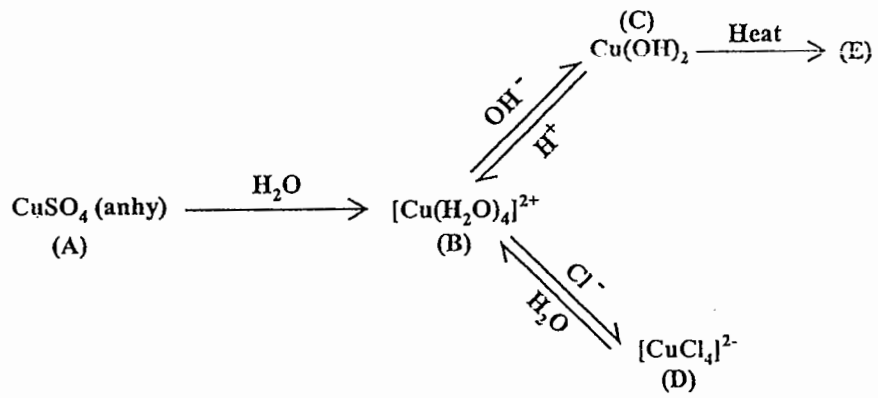

Figure 3. Reaction scheme

(i) Complete the table below by writing the colour of the species labelled A, B, C, D and E in Figure 3.

Species	A	B	C	D	E
Colour					

[5 marks]

(ii) Write the formula of Species E.

_____

[1 mark]

Total 15 marks

SECTION B

Answer ALL questions in this section.

Write your answers in the answer booklet provided.

MODULE 1

FUNDAMENTALS IN CHEMISTRY

4. Valence Shell Electron Pair Repulsion (VSEPR) theory is normally used to predict the shapes and bond angles of simple molecules and ions.

(a) State the basic principle behind the VSEPR theory. **[1 mark]**

(b) When hydrochloric acid reacts with water and ammonia the corresponding hydroxonium and ammonium ions are formed.

(i) Using the VSEPR theory, state the shapes of the hydroxonium (H_3O^+) and ammonium (NH_4^+) ions. **[2 marks]**

(ii) Using suitable diagrams, illustrate the shape of EACH ion in (b) (i). **[2 marks]**

(iii) Account for the shape of EACH of the species, H_3O^+ and NH_4^+. **[4 marks]**

(c) Suggest an explanation for EACH of the following observations:

(i) The experimental determination of the relative molecular mass of ethanoic acid (CH_3CO_2H) produces a value of 120 g. Your answer should include a suitable diagram. **[4 marks]**

(ii) The boiling point of propanone (acetone) is greater than the boiling point of butane. **[2 marks]**

Total 15 marks

MODULE 2

KINETICS AND EQUILIBRIA

5. The following equation represents a step in the Contact Process for the manufacture of sulphuric acid.

Equation 1: $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$; $\Delta H = -196 \text{ kJ mol}^{-1}$

(a) State Le Chatelier's Principle. **[2 marks]**

(b) State the effect of EACH of the following on the equilibrium position of the reaction in Equation 1:

(i) An increase in pressure

(ii) An increase in temperature **[2 marks]**

(c) (i) When SO_2 and O_2 are mixed in a 2 : 1 ratio at 303 K the total equilibrium pressure of the system is 101.3 kPa.

Calculate K_p at 303 K for the reaction in Equation 1, if at equilibrium the number of moles of SO_2, O_2 and SO_3 are 1.2, 0.6 and 0.8 respectively. **[4 marks]**

(ii) Comment on the value for K_p at **695 K** for the reaction in Equation 1. **[1 mark]**

(d) Consider the following equation for a reversible reaction.

Equation 2: $H_2S + H_2O \rightleftharpoons H_3O^+ + HS^-$; $K_a = 8.9 \times 10^{-8}$

(i) Define the term 'Brönsted - Lowry base'. **[1 mark]**

(ii) Identify TWO bases in Equation 2. **[2 marks]**

(e) Calculate the pH of a 0.05 mol dm^{-3} solution of $Ba(OH)_2$. **[3 marks]**

Total 15 marks

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MODULE 3

CHEMISTRY OF THE ELEMENTS

6. (a) Define the term 'electronegativity'. **[1 mark]**

(b) Consider the **chlorides** of the elements in Period 3 of the periodic table, and answer the following questions:

(i) Describe the structures of the chlorides. **[2 marks]**

(ii) Describe the differences in the pH of the solutions formed when the chlorides react with water. **[2 marks]**

(iii) Write the equation for the reaction of silicon(IV) chloride and water. **[2 marks]**

(c) Chlorine forms a colourless solution, P, when dissolved in cold sodium hydroxide. This reaction, which is represented by the reaction below, is referred to as a disproportionation.

$$Cl_2(g) + 2OH^-(aq) \underset{H^+}{\overset{OH^-}{\rightleftharpoons}} Cl^-(aq) + ClO^-(aq) + H_2O(l)$$

(i) What is meant by the term 'disproportionation'? **[1 mark]**

(ii) A suspension is formed when excess silver ions (Ag^+) are added to Solution P. On filtering the suspension and heating the filtrate a white precipitate is formed.

Given the fact that the filtrate contains both Ag^+ and ClO^- ions, account for the presence of the white precipitate on heating. **[2 marks]**

(d) A simple salt, S, when treated with concentrated sulphuric acid produces dense white fumes, T, and a red-brown gas, U.

T, on dissolving in water, produces a colourless solution which turns blue litmus paper red, and gives a cream precipitate, V, on addition of silver ions. V dissolves in aqueous ammonia.

(i) Identify the substances, T, U and V. **[3 marks]**

(ii) Write the formula for the ion present in S. **[1 mark]**

(iii) Write the equation for the formation of the cream precipitate, V. **[1 mark]**

Total 15 marks

END OF TEST