FORM TP 2008167

TEST CODE 22112020

MAY/JUNE 2008

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) (i) Define the term 'standard enthalpy of formation', ΔH_f^{θ}.

_____

_____

_____

[2 marks]

(ii) The enthalpy of formation of both carbon monoxide and aluminium oxide cannot be determined directly by experimental means.

Suggest ONE reason in EACH case for the above observation.

CO : _____

_____

Al_2O_3: _____

_____

[2 marks]

(b) Figure 1 shows the energy level diagram for determining the enthalpy of solution of KBr.

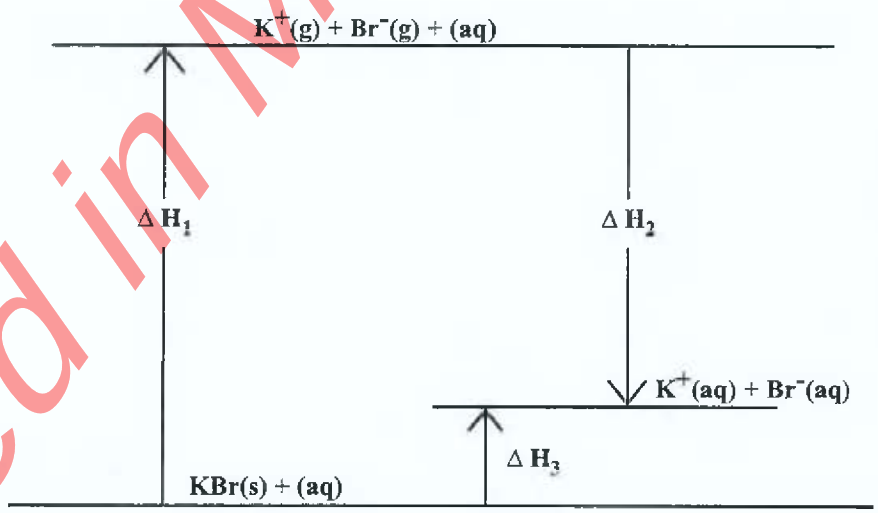

Figure 1. Energy level diagram for determining the enthalpy of solution of KBr

(i) Write the enthalpy change represented by ΔH_1, ΔH_2 and ΔH_3 in Figure 1.

ΔH_1 : _____

ΔH_2 : _____

ΔH_3 : _____

[3 marks]

(ii) Calculate the enthalpy of solution for KBr, given the following information.

$\Delta H_1 = + 672$ kJ mol^{-1} $\Delta H_2 = - 656$ kJ mol^{-1}

[3 marks]

(c) Table 1 provides data comparing the theoretical and experimental (Born-Haber) lattice energies of the halides of elements, X and Y.

TABLE 1: THEORETICAL AND EXPERIMENTAL LATTICE ENERGIES

Compound	Theoretical lattice energy/kJ mol^{-1}	Experimental lattice energy / kJ mol^{-1}
XCl	– 766	– 776
XBr	– 731	– 742
XI	– 686	– 699
YCl	– 768	– 890
YBr	– 759	– 877
YI	– 736	– 867

What kind of bonding is present in

(i) halides of X?

_____

(ii) halides of Y?

_____

[2 marks]

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(d) A student was required to design the method to be followed in determining the enthalpy of neutralisation of hydrochloric acid and sodium hydroxide.

Below is a reproduction of the student's method.

> Measure 25 cm^3 of hydrochloric acid (1M) into a plastic cup using a measuring cylinder.
> Measure the temperature of the acid.
> Transfer 35 cm^3 of sodium hydroxide (1M) into the plastic cup containing the hydrochloric acid. Stir gently with the thermometer and note the resulting temperature of the mixture.

Identify THREE errors in the above method.

(i) _____

_____

(ii) _____

_____

(iii) _____

_____

[3 marks]

Total 15 marks

NOTHING HAS BEEN OMITTED

MODULE 2

KINETICS AND EQUILIBRIA

2. In order to determine the effect of concentration on reaction rates the reaction between butyl chloride (C_4H_9Cl) and water is investigated.

$$C_4H_9Cl\ (aq) + H_2O\ (l) \rightarrow C_4H_9OH\ (aq) + HCl\ (aq)$$

A 0.100 mol dm^{-3} aqueous solution of butyl chloride is reacted with water and the concentration measured at various time intervals to produce the results in Table 2.

TABLE 2: RESULTS OF REACTION OF BUTYL CHLORIDE WITH WATER

Time, t (s)	$[C_4H_9Cl]$ (mol dm^{-3})	Reaction rate (mol dm^{-3} s^{-1})
0.0	0.100	—
50.0	0.090	1.91×10^{-4}
100.0	0.081	1.70×10^{-4}
150.0	0.074	1.59×10^{-4}
200.0	0.067	1.41×10^{-4}
300.0	0.055	1.22×10^{-4}
500.0	0.037	0.801×10^{-4}
600.0	0.030	0.620×10^{-4}
800.0	0.020	0.561×10^{-4}

(a) On the grid provided on page 7, plot a graph of the concentration of butyl chloride, $[C_4H_9Cl]$ on the y-axis against time in seconds, on the x-axis. **[4 marks]**

(b) Using your graph, estimate the concentration of butyl chloride at t = 400 s.

_____

[1 mark]

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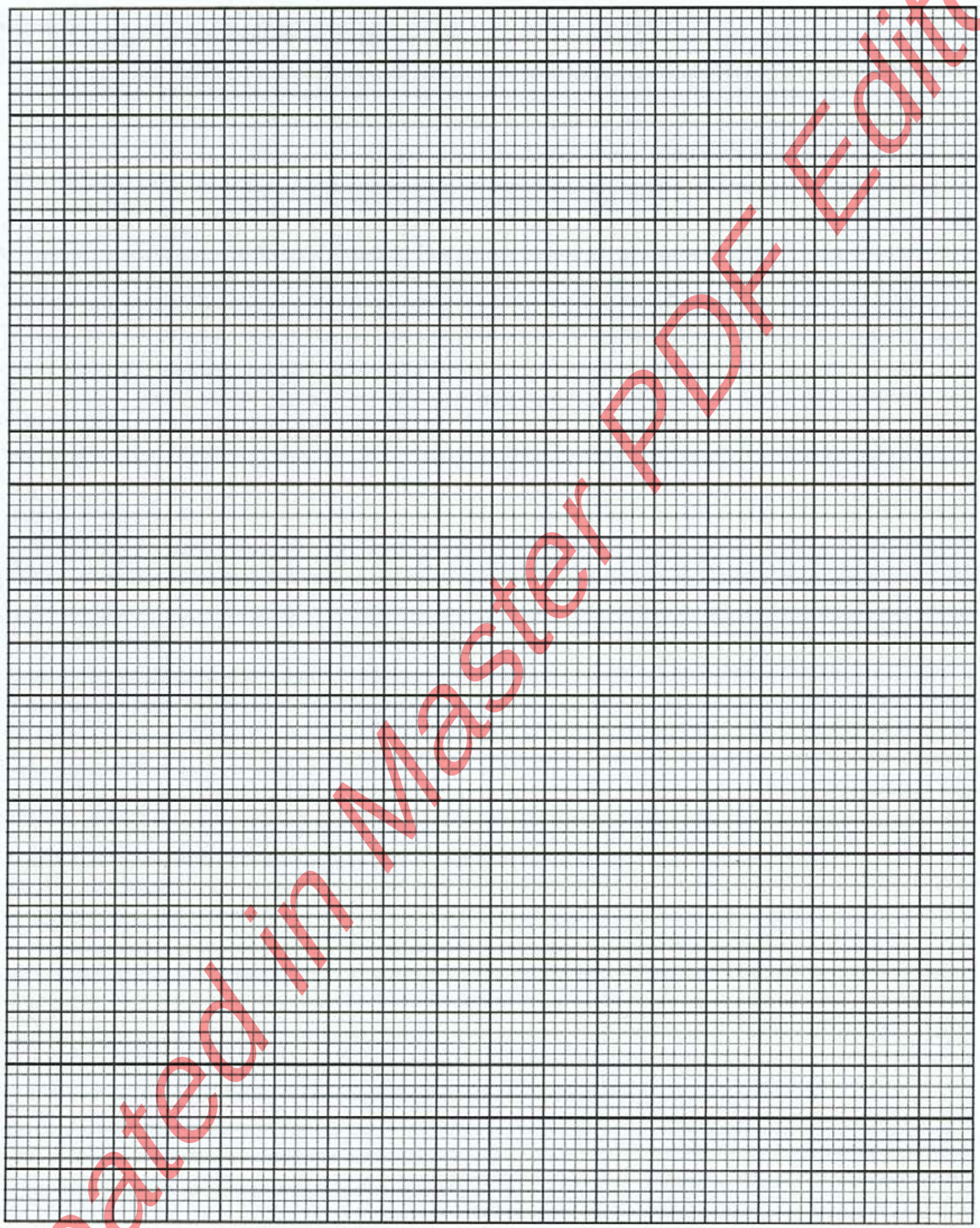

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(c) In addition to concentration, catalysts and temperature also affect reaction rates.

Using suitable well-labelled diagrams, explain how EACH of the following affects reaction rates:

(i) Catalysts

[4 marks]

(ii) Temperature

_____

_____

_____

_____

[4 marks]

(d) Name TWO industrial processes in which catalysts are used.

_____

_____

[2 marks]

Total 15 marks

MODULE 3

CHEMISTRY OF THE ELEMENTS

3. (a) (i) Insert arrows in EACH of the boxes in Figure 2 to show the electronic configuration of the species.

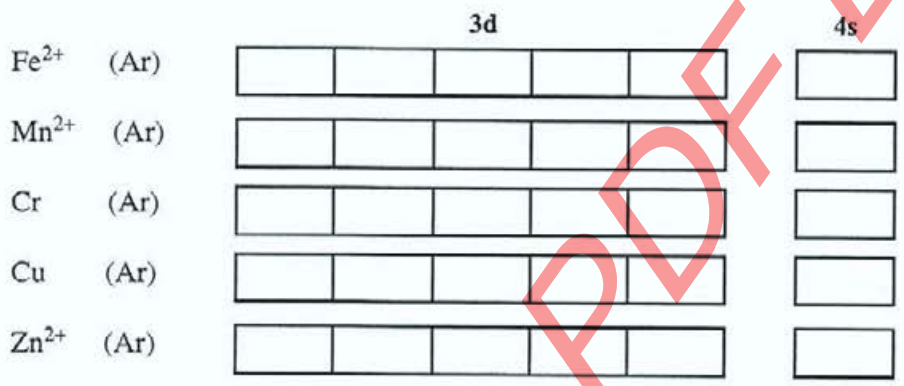

Figure 2. Electronic configuration of different species

(5 marks)

(ii) Explain EACH of the following statements in terms of electronic configurations.

a) Fe^{2+} ions are readily oxidized to Fe^{3+} ions.

_____

_____

b) Mn^{2+} ions are NOT readily oxidized to Mn^{3+} ions.

_____

_____

_____

c) Zn is NOT considered to be a transition element.

_____

_____

[3 marks]

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

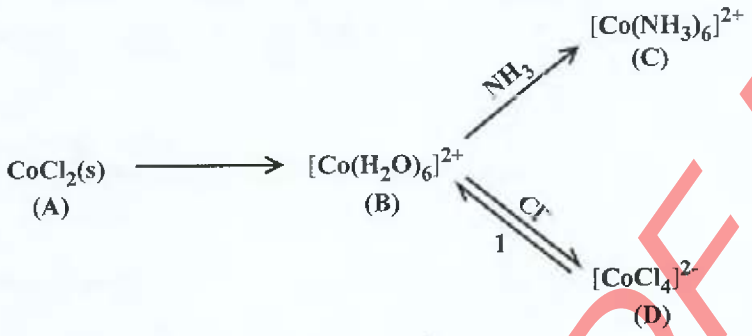

Figure 3. Reaction scheme

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

Species	A	B	C	D
Colour				

[4 marks]

(ii) State the reagent used for the conversion in Reaction 1 (D → B).

_____

[1 mark]

(c) Iron forms a complex ion with cyanide ions (CN^-). The formula of the complex is $[Fe(CN)_6]^{4-}$.

Explain how an aqueous solution of iron(II) sulphate functions as an antidote for cyanide poisoning.

_____

_____

[2 marks]

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. (a) List THREE assumptions made about gas molecules in the kinetic theory. **[3 marks]**

(b) The ideal gas equation is

$$PV = nRT.$$

(i) State the TWO conditions under which the ideal gas equation adequately describes the behaviour of gases. **[2 marks]**

(ii) Carefully explain the deviations produced by real gases. **[3 marks]**

(c) Sketch a graph of volume (V) against the inverse of pressure (1/P) for a constant number of moles of an ideal gas at constant temperature. **[1 mark]**

(d) (i) An organic compound, Y, contains carbon, hydrogen and oxygen only. When vapourised at 101 kPa and 373 K, 1.00 g of Y occupies a volume of 667 cm^3.

Calculate the mass in grams of 1 mole of Y.
(Gas constant, R = 8.314 $J K^{-1} mol^{-1}$).

[4 marks]

(ii) On combustion in excess oxygen, 1 mole of Y produces carbon dioxide and water in the mole ratio 2:3. Deduce the formula of Y. **[2 marks]**

Total 15 marks

MODULE 2

KINETICS AND EQUILIBRIA

5. Buffer solutions are prepared by mixing a weak acid or a weak base with a salt of that acid or base. A buffer solution is prepared using 0.14 mol dm^{-3} lactic acid ($HC_3H_5O_3$) and 0.12 mol dm^{-3} sodium lactate ($NaC_3H_5O_3$). $K_a = 1.4 \times 10^{-4}$ for lactic acid.

$$HC_3H_5O_3(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + C_3H_5O_3^-(aq)$$

(a) With reference to the Bronsted-Lowry theory, explain EACH of the following:

(i) Weak acid

(ii) Strong acid **[2 marks]**

(b) Describe the significance of pH (– log $[H^+]$) and K_a (acid dissociation constant) values. **[2 marks]**

(c) Calculate the pH of the $HC_3H_5O_3$ / $C_3H_5O_3^-$ buffer solution. **[4 marks]**

(d) With the aid of balanced equations, explain how the $HC_3H_5O_3$ / $C_3H_5O_3^-$ buffer works in maintaining its pH. **[6 marks]**

(e) When preparing a buffer solution of a specific pH, state ONE consideration to be taken into account in selecting a suitable weak acid. **[1 mark]**

Total 15 marks

MODULE 3

CHEMISTRY OF THE ELEMENTS

6. (a) Table 3 gives the atomic radii and melting points of the elements in Period 3.

TABLE 3: SOME PROPERTIES OF ELEMENTS IN PERIOD 3

	Na	Mg	Al	Si	P	S	Cl
Atomic radius / nm	0.157	0.136	0.125	0.117	0.110	0.104	0.099
Melting point / °C	98	651	660	1410	44	114	–101

(i) State and account for the trend in the values of the atomic radii across the period from Na to Cl. **[4 marks]**

(ii) The trend in the melting points of the elements in Table 3 is related to structure and bonding.

Describe the trend in the structure of the elements, and the trend in the bonding of the elements in Table 3. **[5 marks]**

(b) (i) Compare the reaction of the Group II elements, Be and Ca, with water. **[2 marks]**

(ii) Describe what happens when barium is treated with water and write the equation for the reaction. **[3 marks]**

(c) State ONE use of calcium carbonate. **[1 mark]**

Total 15 marks

END OF TEST