FORM TP 2017169

TEST CODE 02112020

MAY/JUNE 2017

CARIBBEAN EXAMINATIONS COUNCIL

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

CHEMISTRY

UNIT 1 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of SIX questions in TWO sections. Answer ALL questions.
2. Write your answers in the spaces provided in this booklet.
3. Do NOT write in the margins.
4. Where appropriate, ALL WORKING MUST BE SHOWN in this booklet.
5. A data booklet is provided.
6. You may use a silent, non-programmable calculator to answer questions.
7. If you need to rewrite any answer and there is not enough space to do so on the original page, you must use the extra lined page(s) provided at the back of this booklet. **Remember to draw a line through your original answer.**
8. **If you use the extra page(s) you MUST write the question number clearly in the box provided at the top of the extra page(s) and, where relevant, include the question part beside the answer.**

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

SECTION A

Answer ALL questions.

MODULE 1

FUNDAMENTALS IN CHEMISTRY

1. (a) Define the term 'relative atomic mass'.

.....

.....

.....

[2 marks]

(b) Dalton's atomic theory suggests that

- all atoms of a particular element are identical
- atoms of elements are indivisible.

State TWO pieces of evidence that lead to the rejection of these claims.

.....

.....

.....

.....

[2 marks]

(c) Write the equation which represents the capture of a neutron by a fluorine-19 atom with the resultant expelling of an α-particle.

[2 marks]

(d) Figure 1 shows the mass spectrum of the metal zirconium, Zr.

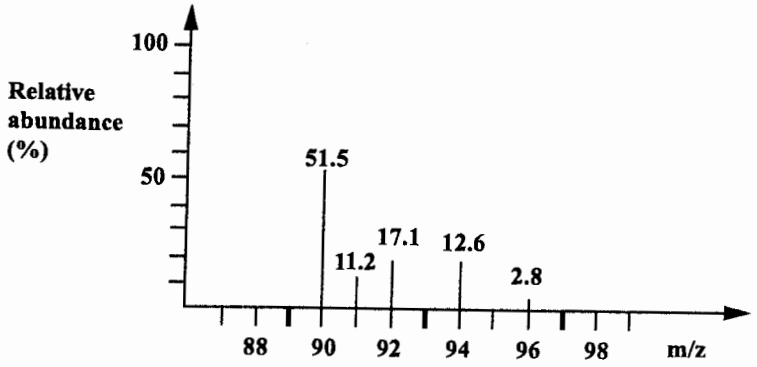


Figure 1. The mass spectrum for zirconium, Zr

Calculate the relative atomic mass of the metal.

[2 marks]

(e) **L**, **M** and **N** are examples of three solid compounds which are ionic, polar and covalent respectively.

Using the format in Table 1, describe THREE simple laboratory tests, stating the corresponding observations, to show the differences between **L**, **M** and **N**.

TABLE 1: TESTS AND OBSERVATIONS

Test	Observation for Compound		
	L	**M**	**N**

[7 marks]

Total 15 marks

MODULE 2

KINETICS AND EQUILIBRIA

2. (a) Define the term 'standard electrode potential'.

.....

.....

.....

.....

[2 marks]

(b) Identify the parts of the standard hydrogen electrode labelled **A** and **B** in Figure 2.

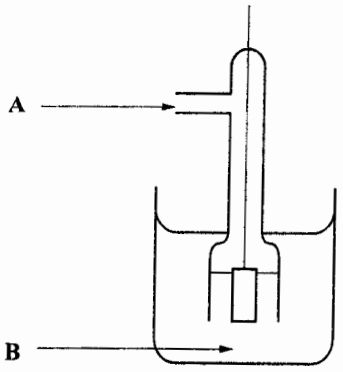


Figure 2. Standard hydrogen electrode

A .....

B .....

[2 marks]

(c) The electrochemical cell at 298 K is represented by the following notation:

$$Pt(s)\,|\,I_2(s),\,I^-(aq)\,\|\,Ag^+(aq)\,|\,Ag(s)$$

(i) Construct a labelled diagram to represent this cell and indicate the direction of electron flow when the cell is operating.

[4 marks]

(ii) Write the relevant equations to represent the change taking place at the anode and the cathode.

Anode: .....

.....

[1 mark]

Cathode: .....

.....

[1 mark]

(iii) Write the balanced equation for the OVERALL cell reaction.

.....

.....

[2 marks]

(iv) Refer to the data booklet to calculate the standard cell potential.

.....

.....

[1 mark]

(d) List TWO types of energy storage devices.

.....

.....

[2 marks]

Total 15 marks

MODULE 3

CHEMISTRY OF THE ELEMENTS

3. $KClO_3$ undergoes disproportionation when heated to just above its melting point to produce KCl and $KClO_4$.

(a) (i) Define the term 'disproportionation'.

.....

.....

.....

[1 mark]

(ii) Write the **balanced** equation for the reaction above and hence deduce the oxidation number of chlorine in $KClO_3$ and $KClO_4$ respectively.

.....

.....

.....

.....

[3 marks]

(b) Explain the trend in volatility of the halogens as the group is descended.

.....

.....

.....

.....

.....

[3 marks]

(c) **MX** is the formula of a salt of the halogen with a relative atomic mass of 80. A student was asked to carry out the following tests on **MX**.

Complete Table 2 to show the student's record of the observations made.

TABLE 2: RECORD OF OBSERVATIONS

No.	Test	Observation
(i)	Warm with concentrated H_2SO_4.	**[2 marks]**
(ii)	Add $AgNO_3$(ag) to MX(aq) followed by concentrated NH_3(aq).	**[2 marks]**
(iii)	Pass Cl_2(g) through MX(aq).	**[1 mark]**

(d) Write an ionic equation to show the oxidizing nature of sulfuric acid in Test (c) (i).

.....

.....

[3 marks]

Total 15 marks

SECTION B

Answer ALL questions.

MODULE 1

FUNDAMENTALS IN CHEMISTRY

4. (a) Apply the concept of the 'hybridization of atomic orbitals' to explain the planarity of the ethene molecule.

.....

.....

.....

.....

.....

.....

[3 marks]

(b) (i) State TWO principles which form the basis of the valence-shell electron pair repulsion (VSEPR) theory.

.....

.....

.....

.....

.....

[2 marks]

(ii) Use the VSEPR theory to account for the difference in shape between the ammonia molecule (NH_3) and the ammonium ion (NH_4^+).

Ammonia molecule (NH_3): .....

.....

.....

Ammonium ion (NH_4^+): .....

.....

.....

[4 marks]

(c) A solution of potassium iodide was made by dissolving 20 g in 1 dm^3 of water. A mixture of 25 cm^3 of this solution and an equal volume of dilute sulfuric acid on titration with 0.02 mol dm^{-3} potassium dichromate(VI) solution needed 24.80 cm^3 for complete oxidation.

Calculate the molar ratio of $Cr_2O_7^{2-}$ to I^- and hence derive the ionic equation for the reaction which has occurred.

Molar ratio:

Ionic equation: .....

.....

[6 marks]

Total 15 marks

MODULE 2

KINETICS AND EQUILIBRIA

5. (a) Explain EACH of the following terms:

(i) Rate law

.....

.....

.....

.....

[2 marks]

(ii) Order of reaction

.....

.....

.....

.....

[2 marks]

(b) Parts (b) (i) to (b) (iii) refer to the following reaction.

$aX + bY \longrightarrow$ Products

(i) Write an expression for the rate law.

.....

.....

.....

.....

[2 marks]

(ii) Write an expression for the OVERALL order of reaction.

.....

[1 mark]

(iii) The overall order of this reaction was found to follow second-order kinetics. Deduce the units of the rate constant for the reaction.

.....

.....

[1 mark]

(c) The decomposition of gaseous nitrogen(V) oxide exhibits first-order kinetics and is represented by the equation

$$2N_2O_5(g) \longrightarrow 4NO_2(g) + O_2(g).$$

A proposed mechanism for the reaction is made up of the following steps (W and Z are intermediates):

$$N_2O_5 \longrightarrow W + O_2$$

$$W \longrightarrow Z + NO_2$$

$$Z + 2N_2O_5 \longrightarrow 3O_2 + N_2O_5$$

Use the information relating to the kinetics of the reaction to write the equation representing the rate determining step. Give a reason for your response.

Equation: .....

Reason: .....

.....

.....

.....

[3 marks]

(d) Data for the decomposition of nitrogen(V) oxide at 333 K is presented in Table 3.

TABLE 3: DATA FOR THE DECOMPOSITION OF NITROGEN(V) OXIDE

Pressure of Nitrogen(V) Oxide Remaining (Pa)	Rate of Reaction (Pa per second)
960	0.83
800	0.70
640	0.55
320	0.27

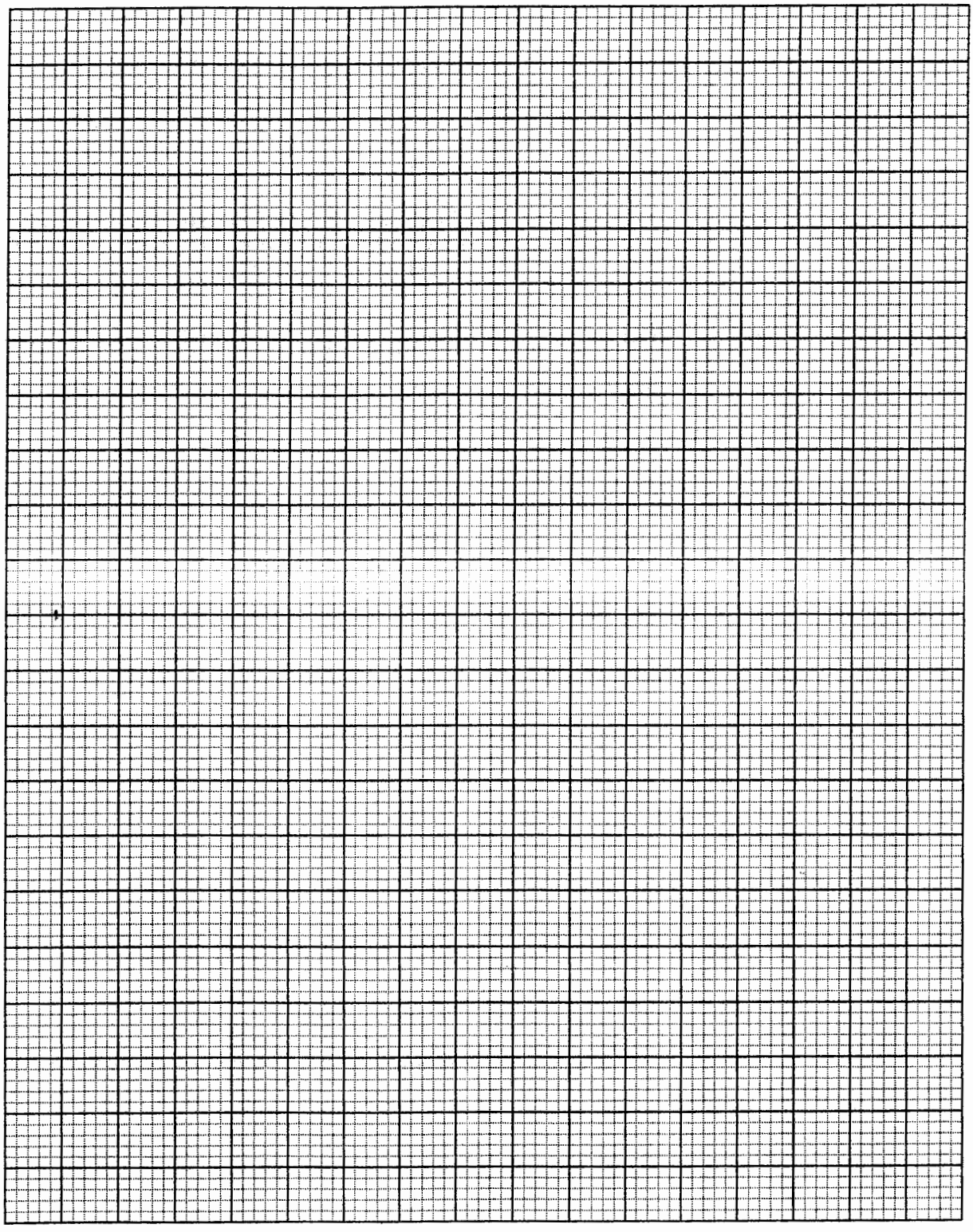
(i) Plot the data on the grid provided **on page 17**, circling the plotted points ⊗.
[2 marks]

(ii) Using the graph in (d) (i), calculate the rate constant for the decomposition of nitrogen(V) oxide at 333 K, stating the appropriate units.

[2 marks]

Total 15 marks

GO ON TO THE NEXT PAGE



MODULE 3

CHEMISTRY OF THE ELEMENTS

6. Table 4 provides information on the atomic radius (AR), ionization energy (IE) and standard electrode potential (E°) for some metals.

TABLE 4: INFORMATION ON THE ATOMIC RADIUS (AR), IONIZATION ENERGY (IE) AND STANDARD ELECTRODE POTENTIAL (E°) FOR SOME METALS

Metal	AR (nm)	IE (kJ mol^{-1})	E° (V)
Beryllium	0.122	1760	–1.85
Magnesium	0.160	1450	–2.37
Calcium	0.197	1150	–2.87
Strontium	0.215	1060	–2.89
Barium	0.225	966	–2.91

(a) Explain, using relevant data from Table 4, the trends in the atomic radius and ionization energy of the metals.

.....

.....

.....

.....

.....

.....

[3 marks]

(b) (i) Describe the difference in the reactions of calcium and barium with water.

.....

.....

[1 mark]

(ii) **Using the data from Table 4, explain the differences described in (b) (i).**

.....

.....

.....

.....

[2 marks]

(c) (i) Describe the difference in the reactions of the chlorides of elements Na, Mg and Al with water.

.....

.....

.....

.....

.....

[2 marks]

(ii) With reference to the ionic radius and electropositivity of the elements, explain the differences in (c) (i) and deduce the type of bonding present in the chlorides.

Differences: .....

.....

.....

.....

.....

.....

.....

.....

Type of bonding: .....

.....

[5 marks]

(d) (i) State how calcium oxide is used in agriculture.

.....

.....

[1 mark]

(ii) Write an ionic equation to represent the process involved in the use **stated** in (d) (i).

.....

.....

[1 mark]

Total 15 marks

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.