FORM TP 2019173

TEST CODE **02112020**

MAY/JUNE 2019

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 THREE questions. 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.

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Answer ALL questions.

MODULE 1: FUNDAMENTALS OF CHEMISTRY

1. Figure 1 shows the wavelengths of the most prominent lines in the visible region of the atomic hydrogen spectrum.

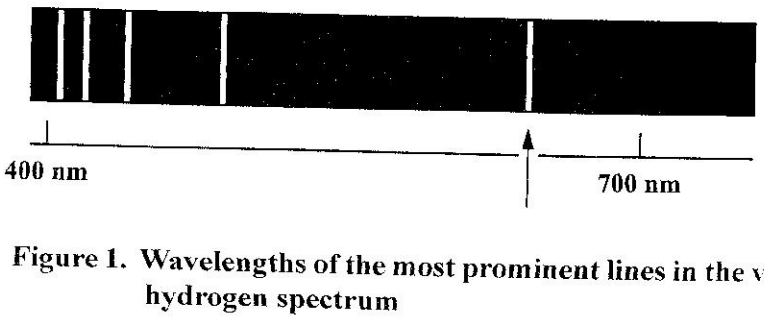

Figure 1. Wavelengths of the most prominent lines in the visible region of the atomic hydrogen spectrum

(a) (i) Explain how the atomic emission spectrum of hydrogen is produced.

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[3 marks]

(ii) Identify the series of lines in Figure 1.

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[1 mark]

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(iii) Assess how the series of lines in Figure 1 provides evidence for discrete energy levels in hydrogen.

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[4 marks]

(iv) In Figure 2, draw the electron transitions occurring between energy levels associated with the origin of the lines in the visible region of the hydrogen spectrum.

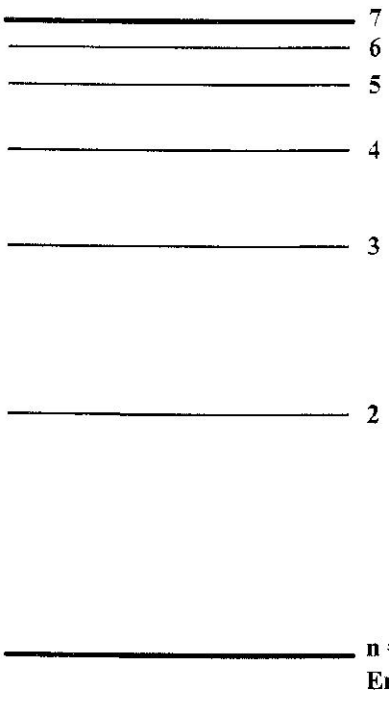

Figure 2. Electron transitions associated with visible region in the hydrogen spectrum

[4 marks]

(b) Hydrogen combines with oxygen to form the compound water. H_2O, and is also present in the hydronium ion, H_3O^+.

(i) Write the electronic configuration of oxygen in its ground state using **s**, **p** notation.

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[1 mark]

(ii) Draw the shapes of the s and p orbitals:

- s orbital

- p orbital

[2 marks]

(iii) Use the VSEPR theory to deduce the arrangement of the orbitals and the shape or bond angles around **each** of the following hydronium ion.

- The oxygen atom in a molecule of water (H_2O)

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- The hydronium ion (H_3O^+)

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[4 marks]

(iv) Explain why the density of ice is lower than expected.

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[3 marks]

(c) Nitrogen combines with hydrogen to form ammonia.

$$N_2(g) + 3\,H_2(g) \rightarrow 2\,NH_3(g) \quad \Delta H_r$$

Using the bond energies from Table 1, determine the enthalpy of reaction, ΔH_r.

TABLE 1: BOND ENERGY VALUE

Bond	Bond Energy kJ/mol
N–N	163
N≡N	945
H–H	436
N–H	390

[3 marks]

(d) Outline an experiment to determine the heat of solution of ammonium nitrate. In your response include

- a labelled diagram of the apparatus
- data to be collected
- how data to be collected can be used to determine the heat of solution.

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[5 marks]

Total 30 marks

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MODULE 2: KINETICS AND EQUILIBRIA

2. (a) (i) Using the Bronsted–Lowry theory, differentiate between a 'strong acid' and a 'weak acid'.

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[2 marks]

(ii) Carbonic acid forms a weak acidic solution in water.

Write an equation to represent the change when carbonic acid is dissolved in water.

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[2 marks]

(iii) State TWO weak acids other than carbonic acid.

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[2 marks]

(b) (i) Define EACH of the following terms:

pH

.....

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pK_a

.....

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[2 marks]

(ii) Calculate the pH of a 0.100 mol dm^{-3} aqueous solution of carbonic acid (K_a of carbonic acid = 4.5×10^{-7}) at the experimental temperature.

[2 marks]

(iii) Determine the pK_a of carbonic acid and compare its strength with an aqueous solution of hydrogen sulfide. (K_a of hydrogen sulfide = 8.9×10^{-8})

[3 marks]

(iv) Sketch a labelled graph to show the pH changes which occur during the titration of 25 cm^3 of 0.10 mol dm^{-3} carbonic acid with 0.10 mol dm^{-3} of sodium hydroxide solution.

[3 marks]

(c) There are several buffers in the blood which have a pH range of 7.35 – 7.45.

(i) Define the term 'buffer solution'.

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[1 mark]

(ii) State the components of TWO buffer systems in the blood.

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[2 marks]

(iii) Explain, using an equation, how ONE of the buffer systems in (c) (ii) operates to maintain the pH of blood when acid is added.

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[2 marks]

(d) Calcium hydroxide preparations are used in restorative dentistry as a therapeutic oral cavity liner.

(i) Write the expression for the solubility product of calcium hydroxide.

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[1 mark]

(ii) Calculate the solubility of calcium hydroxide in g dm^{-3}.
(K_{sp} $Ca(OH)_2$ = 5.5×10^{-6} mol^3 dm^{-9})

[3 marks]

(iii) Outline the experimental steps required to determine the solubility product of calcium hydroxide.

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[5 marks]

Total 30 marks

MODULE 3: CHEMISTRY OF THE ELEMENTS

3. (a) Figure 3 shows the first ionization energies of the Period 3 elements, sodium to argon.

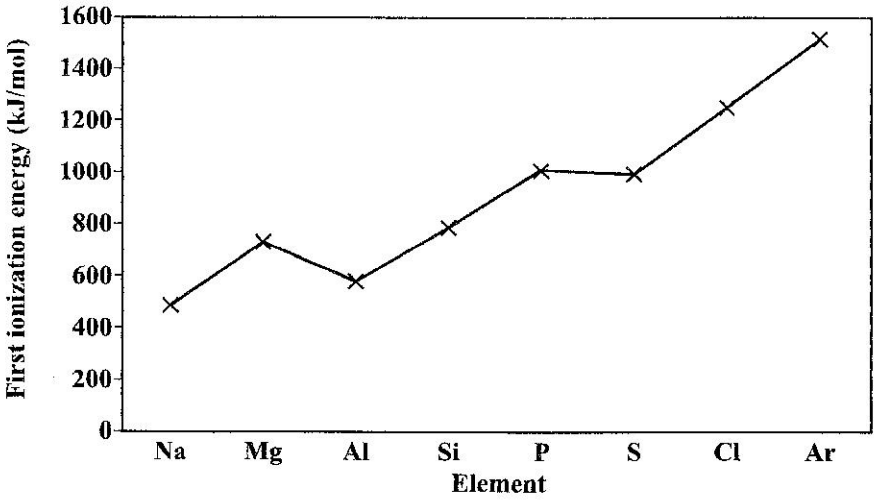

Figure 3. First ionization energies of the Period 3 elements

(i) Write the equation, including state symbols, for the first ionization energy of magnesium.

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[2 marks]

(ii) Explain why there is a **general increase** in the first ionization energies across the period from sodium to argon.

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[2 marks]

(iii) Explain why the first ionization energy of magnesium is greater than that of aluminium.

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[2 marks]

(b) The oxides of the Period 3 elements exhibit variation in their acid-base character as evidenced by their reactions with water. Write a balanced equation to show the reaction between water and EACH of the following Period 3 oxides.

- Na_2O

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- SO_3

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[4 marks]

(c) (i) Describe an experimental method **with expected results** to determine the acid-base nature of the following three Period 3 chlorides.

- NaCl
- $MgCl_2$
- $SiCl_4$

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[5 marks]

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(ii) Write a balanced equation to show the reaction between water and EACH of the following Period 3 chlorides.

- $MgCl_2$

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- $SiCl_4$

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[4 marks]

(d) (i) Define the term 'transition element'.

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[1 mark]

(ii) List THREE characteristic properties of transition elements other than forming coloured compounds.

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[3 marks]

(iii) A sequence of reactions involving compounds of cobalt, with ions A, B and C is shown below.

A **B** **C**

$$[Co(OH)_4]^{2-}(aq) \xrightleftharpoons{H_2O} [Co(H_2O)_6]^{2+}(aq) \xrightleftharpoons{NH_3} [Co(NH_3)_6]^{2+}(aq)$$

Blue

State the colour of the following ions:

B .....

C .....

[2 marks]

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(iv) The electronic configurations of Zn^{2+} and Cu^{2+} are given below

- Zn^{2+} - [Ar] $3d^{10}$
- Cu^{2+} - [Ar] $3d^{9}$

Account for the fact that unlike Cu^{2+} compounds, Zn^{2+} compounds are normally colourless.

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[5 marks]

Total 30 marks

END OF TEST

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