FORM TP 2016166

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MAY/JUNE 2016

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) John Dalton proposed the atomic theory in 1803.

(i) State THREE postulates of Dalton's atomic theory.

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[2 marks]

(ii) Later developments in science led to the modification of the atomic theory. Explain the modification of ONE of the postulates.

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[2 marks]

(b) The dichromate(VI) ion reacts in an acidic medium according to the following half-equation:

$$Cr_2O_7^{2-}(aq) + 14\ H^+(aq) + 6e^- \longrightarrow 2\ Cr^{3+}(aq) + 7\ H_2O(l)$$

(i) Identify the ion responsible for the green colour.

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[1 mark]

(ii) Given that the sulfate(IV) ion, SO_3^{2-}, is converted to the sulfate(VI) ion, SO_4^{2-}, in the presence of water, deduce the balanced equation for the redox reaction between $Cr_2O_7^{2-}(aq)$ and SO_3^{2-}.

[4 marks]

(iii) Identify the oxidizing agent in (b) (ii).

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[1 mark]

(c) The results of two tests are to be recorded in Table 1. Complete the table by inserting the missing observations or inferences.

TABLE 1: RESULTS OF TESTS

Test	Observation	Inference
(i) Chlorine water is added to potassium bromide solution followed by aqueous silver nitrate.	•	• Br^- oxidized to Br_2
	• White precipitate formed	•
(ii) Bromine water is added to potassium chloride solution followed by aqueous silver nitrate.	•	•
	• White precipitate formed on addition of $AgNO_3(aq)$	•

[5 marks]

Total 15 marks

MODULE 2

KINETICS AND EQUILIBRIA

2. (a) Define EACH of the following terms:

(i) Weak acid

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[1 mark]

(ii) K_a

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[2 marks]

(b) In aqueous solution, carbonic acid forms a weak acidic solution containing the hydrogen carbonate ion.

(i) Write an equation to represent the dissociation of carbonic acid in aqueous solution.

[2 marks]

(ii) Write the K_a expression for the reaction in (b) (i).

[1 mark]

(iii) Calculate the pH of a 0.100 mol dm^{-3} aqueous solution of carbonic acid.
($K_a = 4.5 \times 10^{-7}$ mol dm^{-3} at 25 °C.)

[4 marks]

(c) A student was given a particular brand of club soda (carbonated beverage) to determine the carbonic acid content. Outline the experimental steps required for the investigation if the student is given 200 cm^3 of 0.100 mol dm^{-3} sodium hydroxide solution.

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[5 marks]

Total 15 marks

MODULE 3

CHEMISTRY OF THE ELEMENTS

3. Figure 1 shows the melting points of the elements in Period 3.

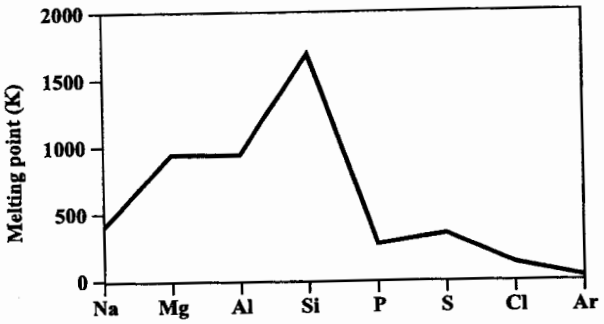

Figure 1. Melting points of elements in Period 3

(a) Explain, in terms of structure and bonding, why

(i) aluminium has a higher melting point than sodium

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[2 marks]

(ii) silicon has the highest melting point in the period

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[2 marks]

(iii) sulfur melts at a higher temperature than phosphorous.

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[3 marks]

(b) The reactions of the oxides of magnesium and phosphorous with water are to be summarized in Table 2.

TABLE 2: REACTION OF OXIDES WITH WATER

Oxide	Reaction with Water	pH of Resulting Liquid
MgO		
P_4O_{10}		

(i) Complete Table 2 by describing the reaction of EACH oxide with water and suggesting a pH value for the resulting liquid. **[2 marks]**

(ii) Write the equation which represents the reaction of water with P_4O_{10}.

[2 marks]

(c) Write equations to show what happens when EACH of the following chlorides reacts with water.

(i) $SiCl_4$

[2 marks]

(ii) $AlCl_3$

[2 marks]

Total 15 marks

SECTION B

Answer ALL questions.

MODULE 1

FUNDAMENTALS IN CHEMISTRY

4. (a) (i) Describe how the bonds are formed in EACH of the solids, potassium chloride and iodine.

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[4 marks]

(ii) Complete Table 3 by comparing the physical properties of potassium chloride (KCl) and iodine (I_2).

TABLE 3: SOME PHYSICAL PROPERTIES OF KCl AND I_2

Properties	KCl	I_2
Melting/Boiling point	High	Low
Electrolytic conductivity	•	•
Solubility in water	•	•

[2 marks]

(b) Account for EACH of the following statements:

(i) The boiling point of H_2O is higher than that of H_2S.

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[3 marks]

(ii) The molecules of aluminium fluoride in the presence of ammonia forms a white solid of formula NH_3AlF_3. (Include an appropriate equation in your account.)

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[3 marks]

(c) Explain the difference between the shapes of NH_3 and NH_4^+.

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[3 marks]

Total 15 marks

MODULE 2

KINETICS AND EQUILIBRIA

5. The following equation represents the reaction between hydrogen and iodine.

$H_2(g) + I_2(g) \rightleftharpoons 2\,HI(g), \quad \Delta H = -10\ kJ\ mol^{-1}$

The reaction is said to be in a state of equilibrium at a particular temperature and pressure.

(a) (i) State FOUR characteristics of a reaction in 'dynamic equilibrium'.

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[4 marks]

(ii) Write the expression for the equilibrium constant in terms of partial pressures, K_p, for the reaction shown by the equation above.

[2 marks]

(iii) State TWO factors which would NOT affect the equilibrium of the reaction shown by the equation above.

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[2 marks]

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(b) Describe the effect of decreasing the temperature on

(i) the equilibrium of the reaction

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[2 marks]

(ii) the value of K_p.

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[2 marks]

(c) When 0.5 mol of hydrogen and 0.5 mol of iodine are allowed to reach equilibrium in a 1.00 dm^3 flask at 500 °C and 1.01×10^5 N m^{-2}, the amount of hydrogen iodide at equilibrium is 0.78 mol. Calculate K_p at 500 °C if the total pressure is 1 Pa.

[3 marks]

Total 15 marks

MODULE 3

CHEMISTRY OF THE ELEMENTS

6. (a) List FOUR properties of transition metals.

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[4 marks]

(b) Titanium(III) chloride forms a violet solution when dissolved in water.

(i) Write the electronic configuration using the s, p and d orbitals of the titanium ion.

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[1 mark]

(ii) Explain the colour of the aqueous solution.

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[4 marks]

(c) (i) Describe what would be observed when concentrated hydrochloric acid is slowly added to an aqueous solution of Co^{2+}.

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[1 mark]

(ii) Write an ionic equation to represent the observation in (c) (i).

[2 marks]

(iii) Using the concept of stability constant, explain the changes observed in (c) (ii).

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[3 marks]

Total 15 marks

END OF TEST

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