TEST CODE **02112020**

FORM TP 2010149

MAY/JUNE 2010

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 answer booklet provided.
4. All working must be shown.
5. The use of silent, 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) State the types of bonds (intra-molecular and inter-molecular) that exist in liquid ammonia.

_____

_____

[2 marks]

(b) Ammonia can be produced by heating calcium oxide with ammonium chloride. The two other products are calcium chloride and water.

(i) Write a balanced chemical equation for the reaction between calcium oxide and ammonium chloride.

_____

_____

[2 marks]

(ii) Calculate the mass of ammonium chloride needed to produce 1 dm^3 of ammonia at RTP (room temperature and pressure).
(Molar volume = 24 dm^3 at RTP)

[2 marks]

(c) (i) Ammonia gas deviates from ideal behaviour. Under which of the following sets of conditions, I, II or III, would the deviation be LEAST?

Conditions	**Temperature (°C)**	**Pressure (kPa)**
I	40	101
II	150	50
III	20	500

[1 mark]

(ii) State TWO assumptions of the kinetic theory as it pertains to ideal gases.

[2 marks]

(iii) Which assumption of the kinetic theory as it pertains to ideal gases would MOST likely account for your answer to (c) (i) above?

[1 mark]

(d) Some ammonia gas is dissolved in water. The exact concentration of the solution is unknown and has to be determined. Describe an experiment that would determine the concentration of the aqueous ammonia.

[5 marks]

Total 15 marks

MODULE 2

KINETICS AND EQUILIBRIA

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

(i) Standard electrode potential of a half-cell

[2 marks]

(ii) Standard cell potential of an electrochemical cell

[2 marks]

(b) Figure 1 is a diagram of an electrochemical cell consisting of a standard copper electrode and a standard aluminium electrode, represented by the notation,

$Al(s) \mid Al^{3+}(aq) \parallel Cu^{2+}(aq) \mid Cu(s)$.

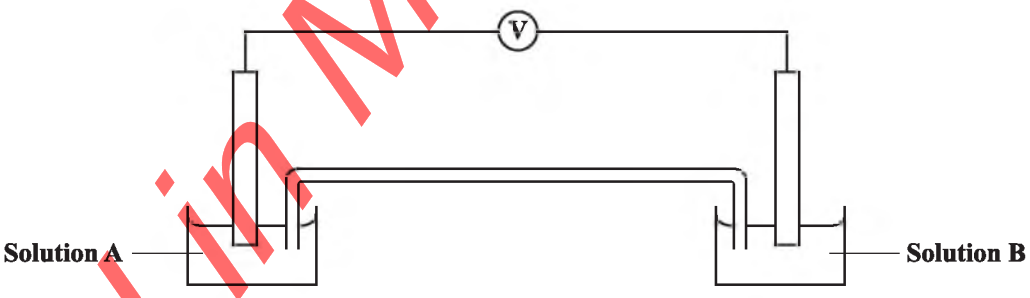

Figure 1. An electrochemical cell with standard copper and aluminium electrodes

(i) On the diagram in Figure 1, label

a) the ions in Solution A and Solution B

b) the salt bridge

c) the cathode and anode

d) the direction of electron flow. **[5 marks]**

(ii) State what would be observed at the cathode after the electrochemical cell in Figure 1 has been running for a few hours.

_____

[1 mark]

(iii) State the experimental conditions used in the preparation of the cell in Figure 1.

Temperature _____

Concentration of Solutions A and B _____

_____

[2 marks]

(iv) Use the information in your Data Booklet to calculate the standard cell potential, E_{cell}, for the electrochemical cell in Figure 1.

[3 marks]

Total 15 marks

MODULE 3

CHEMISTRY OF THE ELEMENTS

3. Ammonium vanadate(V), NH_4VO_3, is an orange solid. Tests are performed on NH_4VO_3 to show the variable oxidation states of vanadium.

(a) Record in Table 1 the observation expected for EACH of the tests below.

TABLE 1: TESTS ON AMMONIUM VANADATE(V)

Test	Observation	Inference
(i) A few cm^3 of bench NaOH is added to a small amount of solid NH_4VO_3, followed by a few cm^3 of dilute H_2SO_4 .	Colour: _____	VO_2^+ formed
(ii) A little granulated zinc is added to the solution in (i) above.	Colour changes to _____ , then to _____ , then to _____, and finally _____	VO_2^+ and VO^{2+} VO^{2+} V^{3+} V^{2+}

[5 marks]

(b) Calculate the oxidation number of vanadium in EACH of the following species:

(i) $VOSO_4$

_____

(ii) VO_2^+

_____

(iii) VO^{2+}

_____

[3 marks]

(c) When concentrated HCl is added to a pink solution of cobalt(II) chloride, the solution turns blue.

Give an explanation for the observation stated above in terms of the stability constant of the complex ion formed, and write a balanced equation for the reaction.

Explanation

Equation

[4 marks]

(d) Complete Table 2 to show the acid/base character of the oxides of Group IV elements in the +2 oxidation state.

TABLE 2: OXIDES OF GROUP IV ELEMENTS

Group IV Oxides	Acid/Base Character
CO	(i)
CO_2	(ii)
SnO	Amphoteric
PbO	(iii)

[3 marks]

Total 15 marks

SECTION B

Answer ALL questions.

Write your answers in the separate answer booklet provided.

MODULE 1

FUNDAMENTALS IN CHEMISTRY

4. (a) Copy and complete Table 3, which provides information on the properties of the simple subatomic particles.

TABLE 3: PROPERTIES OF SIMPLE SUBATOMIC PARTICLES

Particle	Relative Mass	Relative Charge	Location
Electron	$\frac{1}{1840}$	–1	(i) _____
Proton	(ii) _____	+1	Nucleus
(iii) _____	1	(iv) _____	Nucleus

[4 marks]

(b) (i) Radioactive emissions are affected by an electric field. Name the type of radioactive particle that behaves in the same way as the electron. **[1 mark]**

(ii) $^{216}_{84}$Po decays by emitting β particles. State the product formed from the decay of $^{216}_{84}$Po by the emission of three β particles and calculate the n/p ratio of BOTH the reactant and product atoms. **[6 marks]**

(iii) Comment on the effect that the decay has on the stability of the nucleus of $^{216}_{84}$Po. **[1 mark]**

(c) (i) Draw the structures of the atomic orbitals of principal quantum number 2. Include x, y and z axes in the drawing. **[2 marks]**

(ii) Using s, p, d notation, write the electronic configuration of $_{24}$Cr. **[1 mark]**

Total 15 marks

MODULE 2

KINETICS AND EQUILIBRIA

5. A student prepares an ethanoic acid solution of pH 5. He uses this solution to make a buffer.

(a) Define EACH of the following terms:

(i) pH **[2 marks]**

(ii) Buffer solution **[2 marks]**

(b) The acid dissociation constant (K_a) of ethanoic acid at 25 °C has a numerical value of 1.7×10^{-5}. The equilibrium equation for the dissociation of ethanoic acid is

$$CH_3COOH(aq) \rightleftharpoons H^+(aq) + CH_3COO^-(aq).$$

(i) Write an expression for the acid dissociation constant (K_a) of ethanoic acid. **[1 mark]**

(ii) Calculate the equilibrium concentration of ethanoic acid in a solution that has a pH of 5. **[4 marks]**

(c) State the effect, on the equilibrium position of a buffer solution, of adding small amounts of

(i) $H^+(aq)$ **[1 mark]**

(ii) $OH^-(aq)$. **[1 mark]**

(d) A buffer solution is made by adding 20.5 g of sodium ethanoate (CH_3COONa) to 500 cm^3 of 1.5 mol dm^{-3} ethanoic acid. ($K_a = 1.7 \times 10^{-5}$ at 25 °C for ethanoic acid).

Calculate the pH of this buffer solution. **[4 marks]**

(Relative atomic mass: H = 1, C = 12, O = 16, Na = 23)

Total 15 marks

MODULE 3

CHEMISTRY OF THE ELEMENTS

6. The elements in Period 3 of the periodic table are given below.

Na Mg Al Si P S Cl Ar

(a) Account for EACH of the following variations in properties across the period Na to Ar.

(i) Electronegativity increases across the period. **[2 marks]**

(ii) Melting point of the elements increases from Na to Si. **[2 marks]**

(b) Describe the trend in the acid/base character of the oxides of the elements in Period 3. **[3 marks]**

(c) When aluminium chloride dissolves in water, its solution is acidic. Account for the acidic nature of the aluminium chloride solution. **[2 marks]**

(d) Transition metals have higher melting points than metals such as calcium in the s-block of the periodic table. Suggest TWO reasons for this. **[2 marks]**

(e) P_4O_{10} and PCl_5 are the oxide and chloride of phosphorous in its highest oxidation state.

Write an equation to show how EACH of the following reacts with water.

(i) P_4O_{10} **[2 marks]**

(ii) PCl_5 **[2 marks]**

Total 15 marks

END OF TEST