FORM TP 2018170

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MAY/JUNE 2018

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) State Hess' law.

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[1 mark]

(b) The standard enthalpy of formation for potassium fluoride is -562.6 kJ mol^{-1}. Figure 1 shows the energy level diagram for determining the lattice energy of potassium fluoride from experimental data.

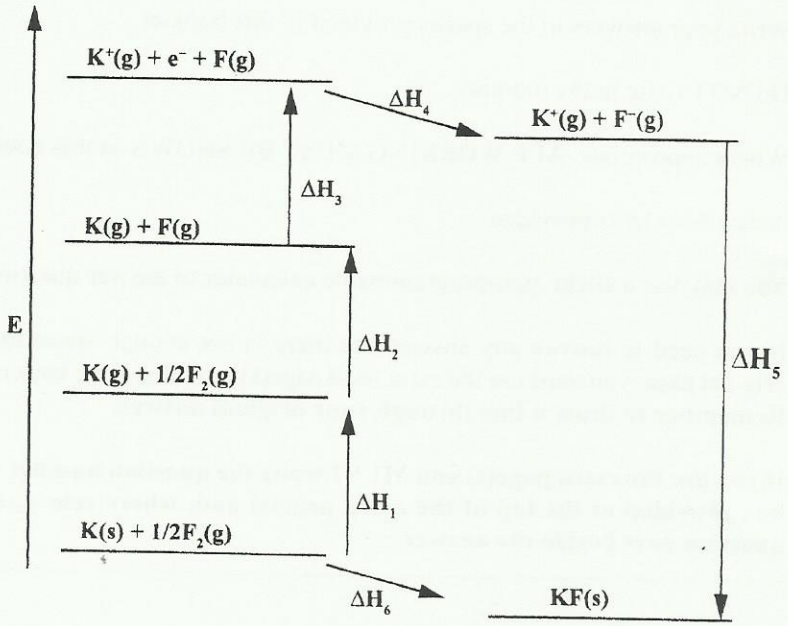

Figure 1. Energy level diagram for determining the lattice energy of potassium fluoride

(i) State the type of enthalpy changes represented by ΔH_1, ΔH_2, ΔH_3 and ΔH_4 in Figure 1.

ΔH_1 .....

ΔH_2 .....

ΔH_3 .....

ΔH_4 .....

[4 marks]

(ii) Calculate the lattice energy of potassium fluoride, given the following information:

$\Delta H_1 = +89.6$ kJ mol^{-1} $\Delta H_2 = +419.0$ kJ mol^{-1}

$\Delta H_3 = +79.1$ kJ mol^{-1} $\Delta H_4 = -332.6$ kJ mol^{-1}

[4 marks]

(iii) Comment on the nature of the bonding in potassium fluoride based on the theoretical lattice energy value of –801.35 kJ mol^{-1}, compared with the experimental value obtained in (b) (ii).

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[2 marks]

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(e) A student is asked to write the steps to be followed in determining the enthalpy of neutralization of 50 cm^3 of 1.0 M hydrochloric acid and 50 cm^3 of 1.0 M of potassium hydroxide. Outline the experimental steps (including calculations) required in the determination.

[Assume that the densities of the solutions of acid and base, and their heat capacities are 1 g cm^{-3} and 4.18 J g^{-1} $°C^{-1}$ respectively.]

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[4 marks]

Total 15 marks

MODULE 2: KINETICS AND EQUILIBRIA

2. (a) State TWO factors which affect the rate of a reaction.

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[2 marks]

(b) The data in Table 1 were obtained for the reaction between hydrogen and nitrogen oxide at 800 °C.

$$2H_2(g) + 2NO(g) \rightarrow 2H_2O(g) + N_2(g)$$

TABLE 1: DATA FOR THE REACTION BETWEEN HYDROGEN AND NITROGEN OXIDE

Experiment Number	Initial Concentration of Hydrogen/mol dm^{-3}	Initial Concentration of Nitrogen Oxide/ mol dm^{-3}	Initial Rate of Production of Nitrogen/ mol dm^{-3} s^{-1}
1	1×10^{-3}	6×10^{-3}	3×10^{-3}
2	2×10^{-3}	6×10^{-3}	6×10^{-3}
3	3×10^{-3}	6×10^{-3}	9×10^{-3}
4	6×10^{-3}	1×10^{-3}	0.5×10^{-3}
5	6×10^{-3}	2×10^{-3}	2.0×10^{-3}
6	6×10^{-3}	3×10^{-3}	4.5×10^{-3}

(i) Define the 'reaction rate' in terms of the production of nitrogen.

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[2 marks]

(ii) From the data, determine the order of the reaction with respect to

hydrogen

[1 mark]

nitrogen oxide.

[1 mark]

(iii) Write the rate law for the reaction.

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[1 mark]

(iv) Calculate the value of the rate constant, k, stating the appropriate units.

[3 marks]

(c) (i) Suggest another experimental technique which would be suitable to investigate the rate of reaction between hydrogen and nitrogen oxide.

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[1 mark]

(ii) The investigation of the effect of concentration on the rate of reaction between aqueous bromine and methanoic acid (in large excess) is catalysed by acid. Outline the experimental steps required.

$$Br_2(aq) + HCOOH(aq) \rightarrow 2Br^-(aq) + 2H^-(aq) + CO_2(g)$$

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[4 marks]

Total 15 marks

MODULE 3: CHEMISTRY OF THE ELEMENTS

3. Table 2 provides data on two properties of the oxides of some Group IV elements.

(a) Complete Table 2 by describing the thermal stability of the oxides. **[4 marks]**

TABLE 2: TWO PROPERTIES OF THE OXIDES OF SOME GROUP IV ELEMENTS

Property	Group IV Element +2 Oxidation State			Group IV Element +4 Oxidation State		
	CO	SiO	PbO	CO_2	SiO_2	PbO_2
Thermal stability		Readily oxidized to dioxide		Stable even at high temperatures		
Melting point of XO_2 or dioxide/°C				–56	1610	290

(b) Account for the type of structure and bonding of the oxides of the elements C, Si and Pb in the +4 oxidation state described in Table 2. Use the melting point data provided in the table to aid your response.

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[3 marks]

(c) Explain the relative stabilities of the oxides of the Group IV elements carbon, silicon and lead, of oxidation states −2 and −4.

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[4 marks]

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(d) Describe the expected observations when

(i) concentrated hydrochloric acid is added to solid lead(IV) oxide

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[2 marks]

(ii) concentrated sodium hydroxide solution is added to solid lead(IV) oxide

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[1 mark]

(iii) an aqueous solution of Fe^{2+} ions is added to solid lead(IV) oxide.

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[1 mark]

Total 15 marks

SECTION B

Answer ALL questions.

MODULE 1: FUNDAMENTALS IN CHEMISTRY

4. (a) State FOUR basic assumptions of the kinetic theory, with reference to an ideal gas.

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[4 marks]

(b) (i) Real gases deviate from ideal gas behaviour under certain conditions of temperature and pressure. Outline TWO assumptions of the kinetic theory of gases which DO NOT hold under these conditions of temperature and pressure.

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[3 marks]

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(ii) **Sketch a graph of PV against P to illustrate the deviation of ONE real gas from ideal gas behaviour.**

[3 marks]

(c) (i) Describe the nature of the liquid state in terms of the motion and arrangement of particles.

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[2 marks]

(ii) A gas syringe contains 18.4 cm^3 of air at 57 °C. When 0.187 g of a volatile liquid is injected into the syringe, the volume of gas in the syringe increases to 54.6 cm^3 at 57 °C and 1.01×10^5 Pa. Calculate the molar mass of the liquid.

[3 marks]

Total 15 marks

MODULE 2: KINETICS AND EQUILIBRIA

5. (a) (i) Define the term 'standard electrode potential of a half-cell'.

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[2 marks]

(ii) Draw a labelled diagram to illustrate how the standard electrode potential of the $Fe^{3+}_{(aq)}/Fe^{2+}_{(aq)}$ half-cell can be measured.

[4 marks]

(iii) State TWO uses of standard electrode potentials.

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[2 marks]

(b) Consider the cell represented below.

$Cu(s) \mid Cu^{2+}(aq) \parallel Ag^{+}(aq) \mid Ag(s)$

(i) Write the equation for the reaction between copper and silver ions.

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[1 mark]

(ii) Calculate the standard cell potential.

[2 marks]

(iii) Assess the feasibility of the reaction.

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[2 marks]

(iv) Assess the effect of an increase in the concentration of silver ions on the standard cell potential.

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[2 marks]

Total 15 marks

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6. Table 3 provides information on the properties of halogens.

TABLE 3: PROPERTIES OF SOME HALOGENS

Property	Fluorine	Chlorine	Bromine	Iodine
State at 20 °C	Gas	Gas	Liquid	Solid
Colour	Pale yellow	Pale green	Red brown	Black
Melting point/°C	–220	–101	–7	113
Bond energy of the hydrides/ kJ per mol of bonds	562	431	366	299
$E^{\ominus}$/V $Hal_2/2Hal^-(aq)/Pt$	+2.87	+1.36	+1.07	–0.54

(a) Explain the trend in volatility of the halogens down the group.

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[2 marks]

(b) Use the $E^{\ominus}$ values and the sodium thiosulfate reagent to explain the relative reactivities of the halogens as oxidizing agents. [Equations are not required.]

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[4 marks]

(c) (i) Describe the reactions of the halogens with hydrogen.

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[4 marks]

(ii) Explain the trend in the relative stabilities of the hydrides.

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[3 marks]

(iii) Write a balanced equation for the reaction of ONE halogen with hydrogen.

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[2 marks]

Total **15 marks**

END OF TEST

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