INNOVA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
Higher 1

CANDIDATE NAME			
CLASS		INDEX NUMBER	

CHEMISTRY

8872/02

24 Aug 2017

2 hours

Paper 2 Structured Questions

Candidates answer on the question paper.

Additional Materials: *Data Booklet*
Writing paper

READ THESE INSTRUCTIONS FIRST

Write your index number, name and civics group on all the work you hand in.
Write in dark blue or black pen.
You may use pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions in the space provided.

Section B
Answer **2 out of 3** questions on writing paper provided.

You are advised to show all working in calculations.
You are reminded of the need for good English and clear presentation in your answers.
You are reminded of the need for good handwriting.
Your final answers should be in 3 significant figures.

You may use a calculator.

The number of marks is given in brackets [ ] at the end of each question or part question.

At the end of the examination, fasten all your work securely together.

For Examiner's Use	
Section A	
1	/15
2	/9
3	/16
Section B	
4	/20
5	/20
6	/20
Significant Figures and Units	
Handwriting and Presentation	
Total	/80

This document consists of **15** printed pages and **1** blank page.

For Examiner's Use

Answer ALL questions on the space provided.

1 **(a)** The element potassium can exist as a number of isotopic species.

Complete the table below for two isotopic species of potassium.

isotopic species	protons	neutrons	electrons	electronic configuration
$^{39}_{19}K$	19			$1s^2$ ……...
		21	18	$1s^2$ ……...

[4]

(b) The structure of an alkene can be determined by identifying the products formed when it undergoes a type of reaction that involves the breakage of the C=C double bond.

In **(i)** and **(ii)** use the products shown to determine the structure of the original alkene.

(i) products: CO_2 and $(CH_3)_2CO$

(ii) products: CH_3CO_2H and $CH_3CH_2CO_2H$

[2]

(c) State the reagent(s) and condition(s) required for the reactions in **(b)(i)** and **b(ii)**.

……...

[1]

(d) State the type of reaction in **(b)(i)** and **b(ii)**.

……...

[1]

For Examiner's Use

(e) Alkenes can be prepared in the laboratory by heating alcohols with excess concentrated sulfuric acid. The set up shown below can be used to prepare a sample of ethene.

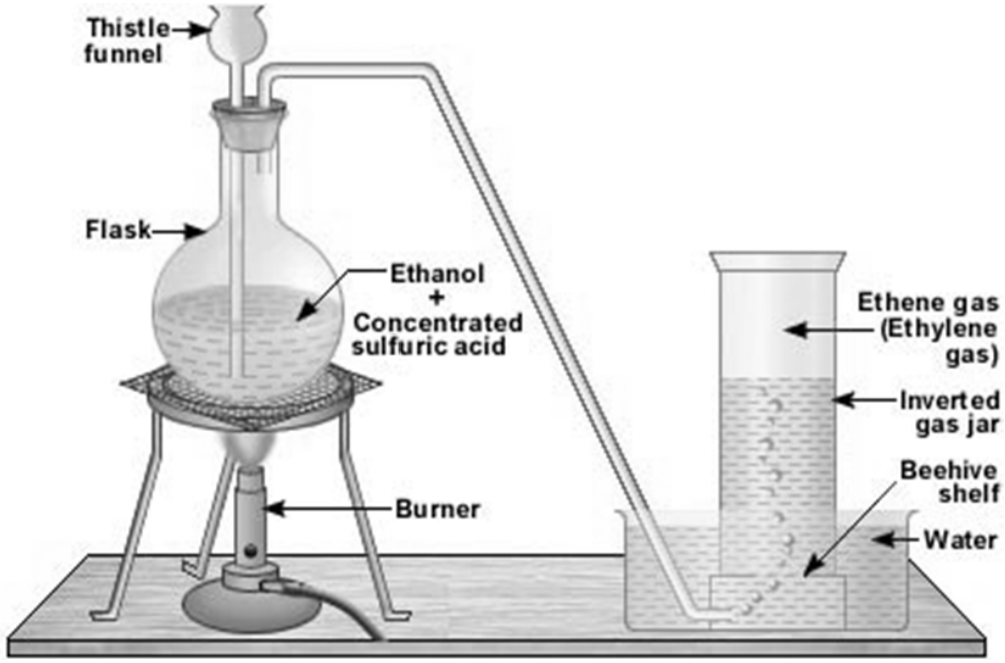

Figure 1.1

From the set up in **Figure 1.1**, the ethene gas collected in the inverted gas jar can be further purified by first bubbling it through another solution **A** and then passing it through a test tube containing anhydrous calcium chloride.

(i) Suggest an identity for solution **A** and explain its purpose.

……...

……...

[2]

(ii) Suggest why anhydrous calcium chloride is required to obtain pure ethene.

……

……

[1]

Ethane-1,2-diol, $CH_2(OH)CH_2(OH)$ may be formed instead of ethene if the water in **Figure 1.1** is replaced with reagent **B**.

(iii) Suggest an identity of reagent **B** and state the condition to be used.

……...

……...

[1]

For Examiner's Use

(iv) What changes do you expect to observe to reagent **B**?

……...

……...
[1]

(v) Suggest one simple chemical test that could be used to distinguish between ethane-1,2-diol and ethanol, and state the observation expected for each compound.

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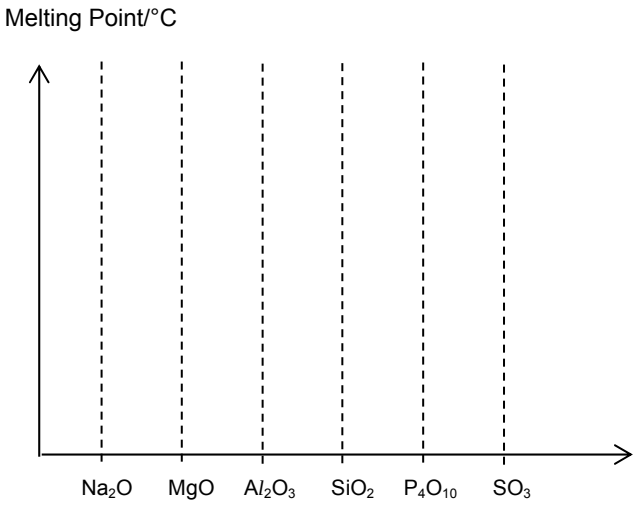
[2]

[Total: 15]

2 (a) (i) The oxides Na_2O, MgO, Al_2O_3, SiO_2, P_4O_{10} and SO_3 differ considerably in their physical properties.

In the space provided below, sketch a graph of the melting point of these oxides.



[2]

For Examiner's Use

(ii) Explain, as fully as you can, why the melting point varies across the oxides of Period 3 elements.

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[4]

(b) Both aluminium and phosphorus can form chlorides.

PCl_5 hydrolyses in water to produce hydrochloric acid and phosphoric acid, $H_3PO_4(aq)$.

$AlCl_3$ also hydrolyses in water to produce an acidic solution.

(i) Write a balanced equation to show the reaction between PCl_5 and water.

……

[1]

(ii) Explain using equation(s) why $AlCl_3$ undergoes hydrolysis with water to produce an acidic solution.

……

……

……

[2]

[Total: 9]

For Examiner's Use

3 Carbonic acid-bicarbonate buffer is the most important buffer for maintaining acid-base balance in our blood. The equilibrium reactions involved are as follows.

$$H^+(aq) + HCO_3^-(aq) \overset{K_1}{\rightleftharpoons} H_2CO_3(aq)$$

$$H_2CO_3(aq) \overset{K_2}{\rightleftharpoons} H_2O(l) + CO_2(g)$$

(a) Carbonic acid-bicarbonate can act as a buffer because they are *conjugate acid-base pair.*

(i) Using H_2CO_3 as an example, what do you understand by the term *conjugate acid-base pair*.

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[1]

(ii) Define the term *buffer*.

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[1]

(iii) Explain how carbonic acid-bicarbonate acts as buffer using relevant equations.

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[3]

For Examiner's Use

(b) During exercise, our body expends the energy in glucose and produces large amounts of CO_2 and H^+. This causes the pH of our blood to drop and may lead to a medical condition known as acidosis. Increased breathing during exercise will help to reverse this drop in pH.

Describe how increased breathing alters the carbonic acid-bicarbonate buffer equilibrium leading to the removal H^+ from the blood.

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[3]

(c) With reference to the equilibrium below, answer the following questions.

$$H^+(aq) + HCO_3^-(aq) \overset{K_1}{\rightleftharpoons} H_2CO_3(aq)$$

(i) Write an expression for the equilibrium constant of this reaction, K_1, stating clearly its units.

[2]

(ii) In our kidney, HCO_3^- is removed from the body. Predict what will happen to the value of K_1.

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……

……

[1]

For Examiner's Use

(d) pH of blood is carefully maintained at 7.4 for our body to function optimally. pH of a carbonic acid-bicarbonate buffer solution can be calculated using modified Henderson-Hasselbalch equation.

$$pH = pK - \log_{10}\left(\frac{[HCO_3^-]}{[CO_2]}\right)$$

where pK is the negative logarithm of K (where $K = K_1.K_2$).

(i) Given the value of pK is 6.1, calculate the ratio of $[CO_2]$ and $[HCO_3^-]$ in our blood.

[1]

(ii) The desired concentration of HCO_3^- in the blood is 12 millimole per litre. Using your answer in **(d)(i)**, what is the corresponding concentration of CO_2 in mol dm^{-3}?

[1]

(iii) Calculate the mass of $NaHCO_3$ that needs to be dissolved in 1 dm^3 of water to obtain the desired concentration of HCO_3^- in a lab setting.

[1]

For Examiner's Use

(e) Besides exercise, alcohol beverage consumption can also lead to acidosis. This occurs when lactic acid, 2-hydroxypropanoic acid, is formed when ethanol is metabolised in the body.

The main component in alcohol beverages is ethanol.

(i) Ethanol can be converted to ethanoic acid. State the reagent(s) and condition(s) for this reaction in a lab setting.

Reagent(s) and condition(s)

……

……
[1]

(ii) Explain why lactic acid cannot be formed using its corresponding alcohol in the lab setting.

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[1]

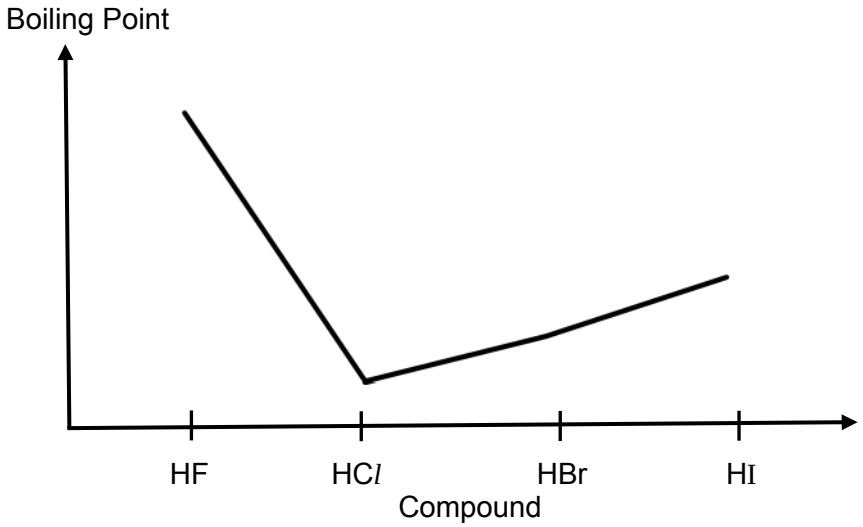
[Total:16]

SECTION B (Free Response Questions)

Answer **two** questions from this section on separate answer paper.

4 Hydrogen halides are diatomic inorganic compounds with the formula HX where X is one of the halogen atoms: fluorine, chlorine, bromine, iodine or astatine. They exist as gases that dissolve in water to give acids which are commonly known as hydrohalic acids.

The boiling points of hydrogen halides are shown in the graph below.



(a) **(i)** Explain why the boiling point of HF is the highest.

[2]

(ii) Explain why the boiling points of hydrogen halides increase from HCl to HI.

[2]

(b) With the aid of a diagram, draw the type of bonding present between HF molecules.

[2]

(c) Explain if hydrohalic acids are able to conduct electricity when dissolved in water.

[1]

At high temperature, hydrogen iodide partially dissociates into hydrogen and iodine according to the equation:

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g) \quad \Delta H > 0$$

At 500K, the equilibrium constant, K_c, for the dissociation reaction is 6.25×10^{-3}. Some pure HI is placed into an evacuated glass tube and heated to 500K. In the equilibrium sample, the concentration of I_2 is 3.10×10^{-5} mol dm^{-3}.

(d) **(i)** Determine the concentrations of HI(g) in this equilibrium mixture at 500K.

[1]

(ii) Hence, calculate the initial concentration of HI added originally.

[1]

(iii) Suggest and explain how the value of K_c would change if the temperature of the glass tube was raised.

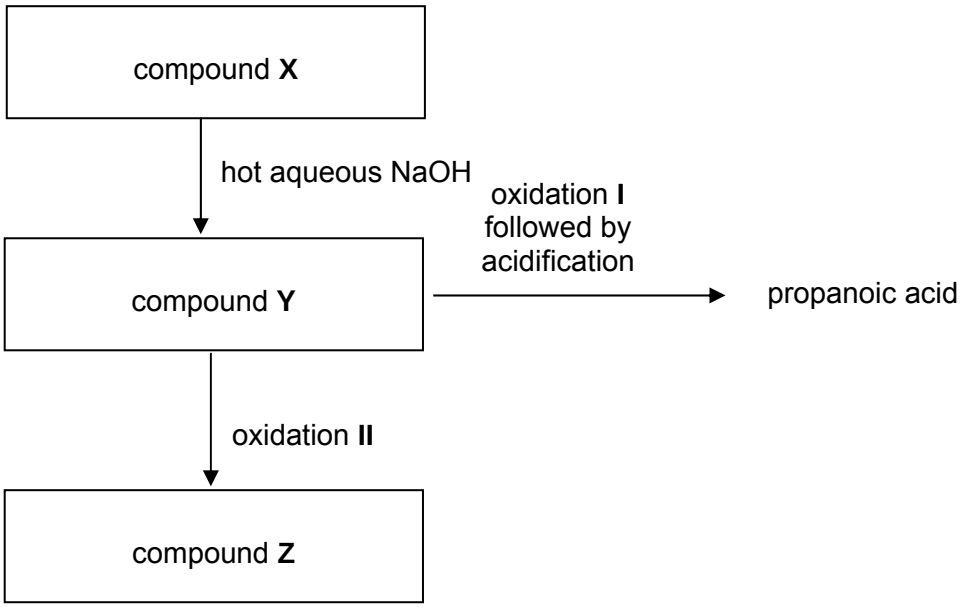
[2]

(e) Compound **X** is a halogenoalkane with molecular formula C_4H_9Cl. When heated under reflux with aqueous NaOH, compound **Y** is formed.

Compound **Y** is able to undergo oxidation with two different sets of reagents and conditions. Using the first set of reagents and conditions, followed by acidification, propanoic acid is formed. However, when compound **Y** is oxidised using the second set of reagents and conditions, product **Z** is formed. Compound **Z** reacts with 2,4 -dinitrophenylhydrazine but not with Tollens' reagent.

(i) Using the information given above and the flow chart below, deduce and draw the structures of compounds **X**, **Y** and **Z** in your writing paper.

[3]



(ii) State the reagents and conditions for oxidation **I** and oxidation **II**.

[2]

(iii) Predict the shape and bond angle about Cl – C – H in compound **X**, C_4H_9Cl.

[2]

(iv) State and explain whether compound **X**, C_4H_9Cl is polar or non-polar.

[2]

[Total: 20]

5 This question is about chlorine.

(a) Due to its toxic nature, chlorine was used as an offensive weapon in World War I in Flanders. It was first deployed in 1915 when the German army released the gas from hundreds of cylinders. The threat of causing many men dying in agony was eventually countered by issuing gas masks, termed the "hypo helmet", which was a hood that was dipped in aqueous sodium thiosulfate, $Na_2S_2O_3$.

(i) When chlorine gas was absorbed by sodium thiosulfate found in the "hypo helmet", chlorine was reduced to chloride while thiosulfate ions, $S_2O_3^{2-}$ was oxidised to sulfate ions, SO_4^{2-}.

Write a balanced equation for the reaction between chlorine and thiosulfate ions in an acidic medium.

[1]

(ii) Assuming that each treated "hypo helmet" effectively absorbed 500 cm^3 of chlorine gas during a battle at room temperature and pressure, and the production of each "hypo helmet" required 700 cm^3 of aqueous sodium thiosulfate, calculate the concentration in mol dm^{-3} of sodium thiosulfate required. [You may assume the mole ratio between Cl_2 and $S_2O_3^{2-}$ to be 2 : 3 if you are not able to write the equation between Cl_2 and $S_2O_3^{2-}$]

[3]

(b) Chlorine reacts with the Period 3 elements magnesium to phosphorus to form their chlorides. The melting point of these chlorides are given in the table below.

compound	magnesium chloride	aluminium chloride	phosphorus pentachloride
melting point/^oC	714	178	161

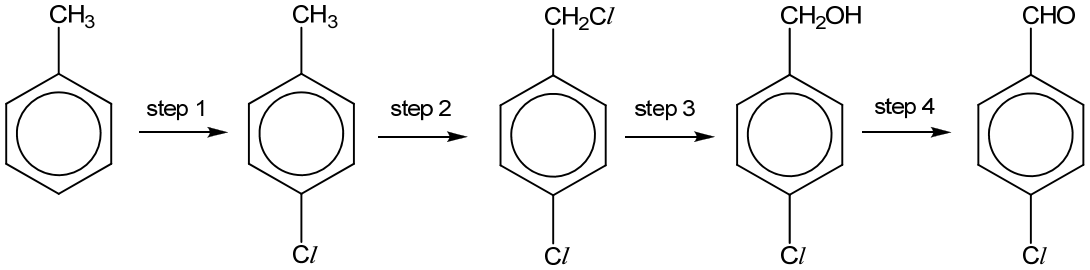
(i) Draw the Lewis structure of phosphorus pentachloride.

[1]

(ii) $AlCl_3$ can undergo dimerisation to form Al_2Cl_6. Draw the dot-and-cross diagram for $AlCl_3$ and Al_2Cl_6. Hence, or otherwise, deduce, with reasoning, whether the dimerisation reaction is endothermic or exothermic.

[3]

(c) Chlorine has landed its use in Organic Chemistry as shown in the reaction scheme below.



(i) Suggest suitable reagents and conditions for steps 1, 2 and 4.

[3]

(ii) State the type of reaction for step 3.

[1]

(d) The following results were obtained when chloroalkane, RC*l* reacted with aqueous sodium hydroxide.

Expt	Initial [NaOH] / mol dm^{-3}	Initial [RC*l*] / mol dm^{-3}	Initial rate / mol dm^{-3} s^{-1}
1	0.02	0.0150	4.0×10^{-4}
2	0.02	0.0225	6.0×10^{-4}
3	0.03	0.0225	9.0×10^{-4}

(i) Deduce the orders of reaction with respect to each of the reactants. Hence, write the rate equation for the reaction.

[3]

(ii) In Expt 4, the initial concentrations of NaOH and RC*l* are 0.06 mol dm^{-3} and 0.03 mol dm^{-3} respectively. Calculate the initial rate for Expt 4.

[1]

(iii) Describe and explain, with an appropriate diagram, how the rate of this reaction is affected when the experiment is repeated at a higher temperature.

[4]

[Total: 20]

6 **(a)** Carbonates, CO_3^{2-} and hydrogencarbonates, HCO_3^{2-} react with acids in the following manner.

Reaction **A** $CO_3^{2-}(aq) + 2H^+(aq) \longrightarrow H_2O(l) + CO_2(g)$
Reaction **B** $HCO_3^-(aq) + H^+(aq) \longrightarrow H_2O(l) + CO_2(g)$

A student mixed 40.0 cm^3 of 1.0 mol dm^{-3} of an unknown solution and 40.0 cm^3 of 1.0 mol dm^{-3} of nitric acid, $HNO_3(aq)$. The temperature fell by 1.5 ºC.

The unknown solution is either sodium carbonate, Na_2CO_3 or sodium hydrogencarbonate, $NaHCO_3$.

(i) Use the standard enthalpy change of formation values in the table below to calculate the standard enthalpy change for reactions **A** and **B**.

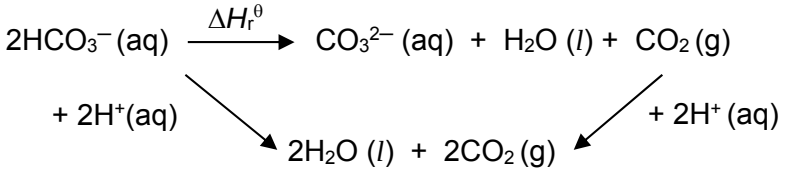
	ΔH_f^θ / kJ mol^{-1}
$H_2O(l)$	– 285.8
$CO_2(g)$	– 393.5
$HCO_3^-(aq)$	– 692
$CO_3^{2-}(aq)$	– 677
$H^+(aq)$	0.0

[2]

(ii) Use your answer in **(a)(i)** to determine which of the two equations, **A** or **B**, represents the reaction that has occurred. Explain your answer.

[3]

(b) Using the energy cycle provided, calculate the enthalpy change, ΔH_r^θ for the following reaction.



[2]

(c) Propanoic acid, CH_3CH_2COOH, can also react with carbonates and hydrogencarbonates.

(i) Explain in terms of its structure why 2-chloropropanoic, $CH_3CH(Cl)COOH$ acid is more acidic than propanoic acid.

[2]

(ii) Describe how you would convert propanoic acid to propan-1-ol, $CH_3CH_2CH_2OH$. Include the reagents and equation in your answer.

[2]

(d) How will propanal, CH_3CH_2CHO react with the following reagents?

In each case, write an equation to illustrate your answer and state what type of reaction is taking place.

(i) hydrogen cyanide, HCN, in the presence of sodium hydroxide,

[2]

(ii) 2,4-dintirophenylhydrazine reagent,

[2]

(ii) sodium borohydride, $NaBH_4$

[2]

(e) Describe one simple chemical test that could distinguish between propanoic acid and propan-1-ol.

[3]

[Total: 20]

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