Name:	Index No.:	CT Group: 14

PIONEER JUNIOR COLLEGE

2015 JC2 PRELIMINARY EXAMINATION
HIGHER 1

CHEMISTRY **8872/02**
Paper 2

15 September 2015

Candidates answer Section A on the Question Paper

Additional Materials: Data Booklet
Writing Paper

2 hours

READ THESE INSTRUCTIONS FIRST

Write your name, index no and CT group on all the work you hand in.
Write in dark blue or black pen.
You may use a pencil for any diagrams, graphs or rough working.

Section A
Answer **all** questions.

Section B
Answer any **two** questions on separate writing paper. Begin each question in a fresh sheet of writing paper.

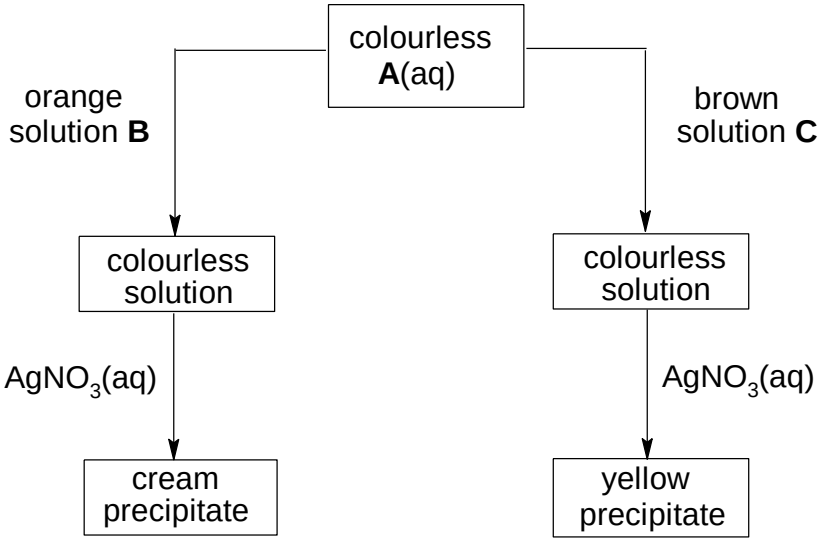
At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

FOR EXAMINER'S USE			
Section A		**Section B**	
1	/ 9	5	/ 20
2	/ 9	6	/ 20
3	/ 10	7	/ 20
4	/ 12	Penalty	s.f. / units
		TOTAL	**/ 80**

Section A (40 marks)

Answer all questions in the spaces provided.

1 The diagram below shows the reactions of an aqueous salt, **A**.



A has the following composition by mass:

K, 41.1%; S, 33.7%; O, 25.2%.

The relative formula mass, M_r, of **A** is 190.4. One formula unit of **A** contains only one type of anion.

(a) Determine the formula of the salt **A**.

[2]

(b) Give the identities of the cream precipitate and the yellow precipitate.

Cream precipitate: ……..

Yellow precipitate: ……..

[1]

(c) Suggest the identities of **B** and **C**.

B: ……...

C: ……...
[1]

(d) With reference to the *Data Booklet*, show, by means of **two** ionic equations, how the yellow precipitate is formed from **C**.

……

……

……[2]

(e) For the reaction of **A** and **B**, a titration was carried out to determine if the sulfur-containing product is $S_4O_6^{2-}$ or SO_4^{2-}.

It was found that 25.0 cm^3 of 0.200 mol dm^{-3} of **B** required 10.0 cm^3 of 0.125 mol dm^{-3} of **A** for complete reaction.

Use the data to determine the final oxidation state of sulfur in the product. Hence, write a balanced equation for the reaction of **A** and **B**.

[3]

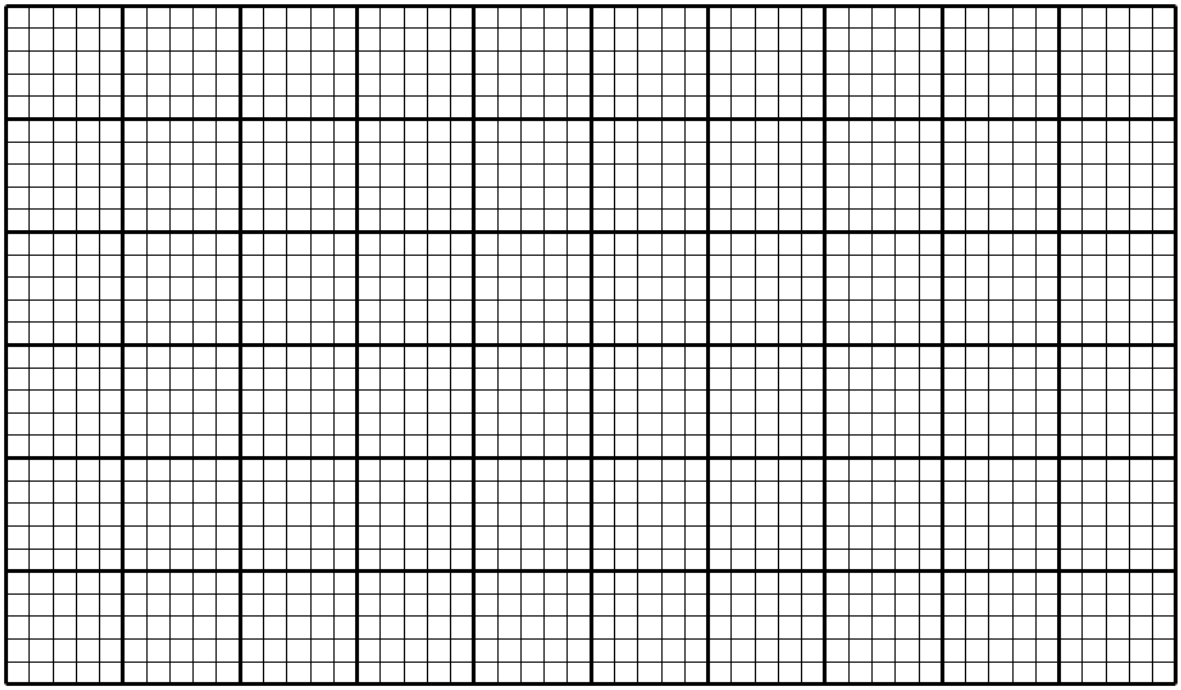
[Total: 9]

2 For a reaction **X** → **Y**, the following experimental results were obtained.

Time / s	0	20	40	60	80	100	120	140	∞
[**Y**] / mol dm^{-3}	0	0.12	0.20	0.26	0.30	0.33	0.35	0.37	0.40

When the reaction is complete, the concentration of **Y** is 0.40 mol dm^{-3}.

(a) Plot the graph of [**Y**] against time on the grids below to find the half-life of the reaction. Hence, determine the order of reaction with respect to **X**.



[4]

(b) Determine the initial rate of the reaction.

[1]

(c) Hence, calculate the rate constant, stating its units, given that the initial concentration of **X** is 0.40 mol dm^{-3}.

[1]

(d) With the aid of a sketch of the Boltzmann Distribution, explain why an addition of catalyst increases the rate of reaction.

……

……

……

……

……

……[3]

[Total: 9]

3 **(a)** Describe what you would see when sodium burns in oxygen and write the balanced equation, with state symbols, for the reaction described.

……

……

……

……[2]

(b) Describe what you would see when the residue from **(a)** is dissolved in water containing Universal Indicator solution. Write balanced equation, with state symbols, for the reaction described.

……

……

……

……[2]

(c) Each of the following oxides can react with sodium hydroxide and/or hydrochloric acid. For **each** oxide, write a balanced equation for its reaction with either hydrochloric acid or sodium hydroxide.

- magnesium oxide

……

- aluminium oxide

……

- phosphorus(V) oxide

……

[3]

(d) Explain, in terms of structure and bonding, why aluminium oxide melts at 2070 ºC while aluminium chloride sublimes at 178 ºC.

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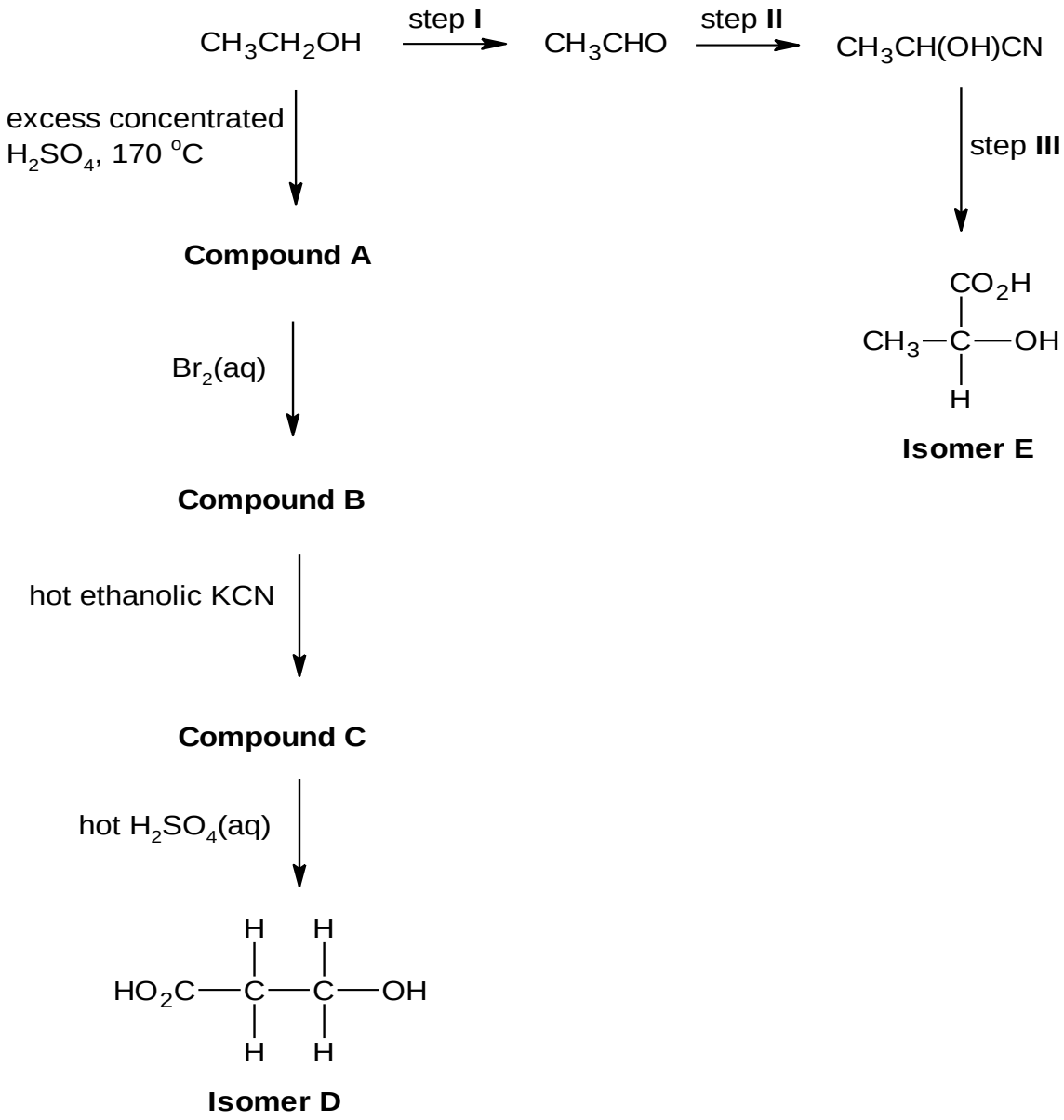
……[3]

[Total: 10]

4 (a) Consider the following reaction scheme, starting from ethanol.



(i) Suggest reagents and conditions for steps **I**, **II** and **III**.

step **I**: .....

step **II:** .....

step **III**: .....

(ii) Draw the structures of compounds **A**, **B** and **C** in the boxes below.

Compound **A**	Compound **B**

Compound **C**

[6]

(b) **(i)** The two isomers **D** and **E** are subjected to a chemical test which is able to distinguish them. Give the test reagent and condition and write the observations for each of the isomers.

Isomer	**D**	**E**
Test reagent and conditions		
Observations		

(ii) Write a balanced equation for the reaction between your suggested test reagent and the isomer that gives a positive result.

.

……

(iii) State the type of isomerism exhibited by isomers **D** and **E**.

……

(iv) How do you expect the acidity of isomer **D** to compare with that of isomer **E**? Explain your answer.

……

……

……

……

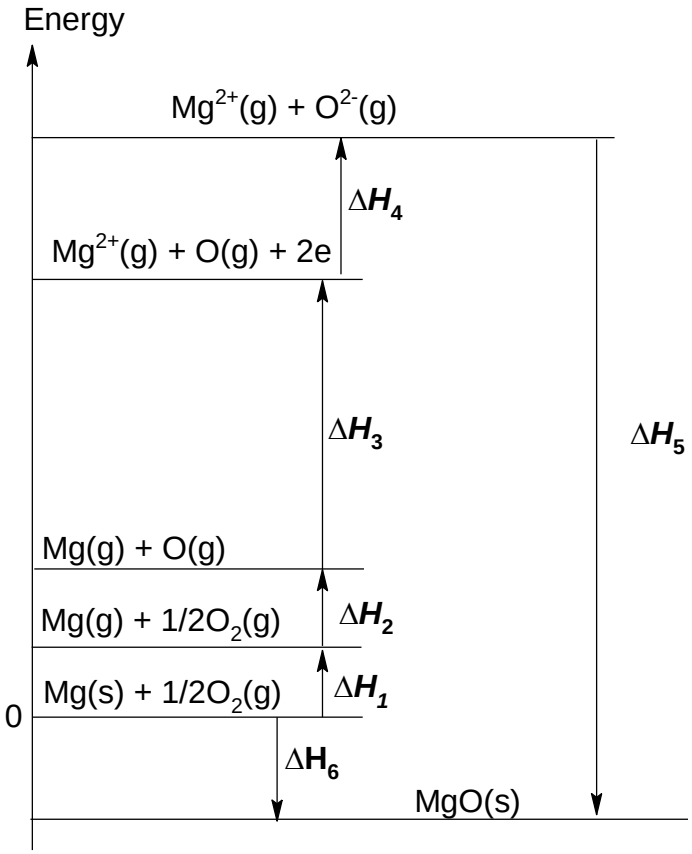
[6]

[Total: 12]

Section B

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

5 (a) The formation of magnesium oxide from its elements may be represented by a Born-Haber energy cycle shown below.



(i) Name the enthalpy changes represented as ΔH_3, ΔH_5 and ΔH_6.

(ii) Using relevant information from the *Data Booklet* and the following information, calculate the lattice energy of magnesium oxide.

$Mg(s) \rightarrow Mg(g)$	$\Delta H_1 = +150\ kJmol^{-1}$
$O(g) + 2e \rightarrow O^{2-}(g)$	$\Delta H_4 = +606\ kJmol^{-1}$
$Mg(s) + ½O_2(g) \rightarrow MgO(s)$	$\Delta H_6 = -602\ kJmol^{-1}$

(iii) Suggest, with reasons, how the magnitude of lattice energy of $MgF_2(s)$ might compare with that of MgO(s).

[7]

(b) Research shows that apple juice is a good alternative to soda and other soft drinks, especially because it contains vitamin C and healthy polyphenol antioxidants that are essential for overall health.

Apple juice, which contains a monobasic acid **HA**, has a pH of 3.5 and it can be titrated with standard alkali. A 25.0 cm^3 sample of apple juice was exactly neutralised by 27.50 cm^3 of 0.10 mol dm^{-3} sodium hydroxide using phenolphthalein as an indicator.

(i) Calculate the concentration of hydrogen ions, in mol dm^{-3}, in apple juice.

(ii) Calculate the concentration of **HA**, in mol dm^{-3}, in the juice.

(iii) Based on your answer in **(b)(i)** and **(b)(ii)**, comment on the acid strength of **HA** present in the juice.

(iv) Write an expression for the acid dissociation constant, K_a, for the acid **HA**.

(v) Using your answers in **(b)(i)** and **(b)(ii)**, calculate a numerical value of the acid dissociation constant, K_a.

(vi) With the aid of two equations, explain how an aqueous solution of the acid (**HA**) and its sodium salt ($\mathbf{Na^+}$ $\mathbf{A^-}$) acts as a buffer on addition of small amount of acid and alkali.

(vii) Suggest a reason why phenolphthalein is a suitable indicator for this titration.

[8]

(c) Methyl butanoate is a colourless liquid with a fruity apple smell. It can undergo hydrolysis in the presence of an acid or alkali.

(i) Write equations showing how methyl butanoate undergoes hydrolysis using

- HC*l*(aq)
- NaOH(aq)

(ii) Compound **P** is isomeric with methyl butanoate. Upon hydrolysis, **P** gives ethanoic acid and alcohol **Q**. **Q** undergoes tri-iodomethane (iodoform) reaction.

Give the name of alcohol **Q** and draw the structure of **P**.

(iii) Compound **R** is also isomeric with methyl butanoate. Effervescence is observed when Na_2CO_3(aq) is added to **R**.

Suggest a structure for **R**.

[5]

[Total: 20]

6 (a) The Haber process is the nitrogen fixation reaction of hydrogen gas which is used industrially to produce ammonia. The reaction takes place over finely divided iron catalyst.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92 \text{ kJ mol}^{-1}$$

100 moles of nitrogen and 300 moles of hydrogen gas are heated at 470 ^{o}C in a 100 dm^3 reaction vessel until equilibrium is established. The equilibrium mixture contains 80 moles of ammonia.

(i) Write the expression for K_c.

(ii) Calculate a value for K_c, giving its units.

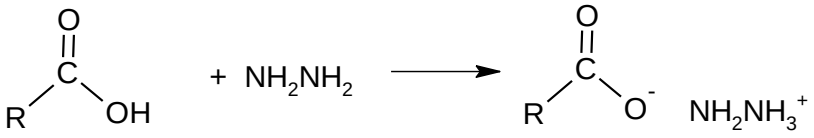
(iii) State and explain how a decrease in temperature affects the yield of NH_3.

(iv) Draw a fully labelled reaction pathway diagram for the catalysed reaction. On the same diagram, show how the reaction pathway diagram would differ if the catalyst was not used.

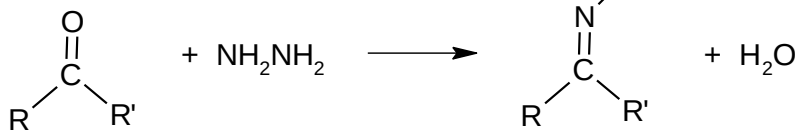
[7]

(b) Hydrazine, N_2H_4, has an ammonia-like odour and is derived from the same industrial chemical processes that manufacture ammonia.

Hydrazine can react with carboxylic acids and carbonyl compounds as shown in the following two reactions respectively.



Reaction 1



Reaction 2

where R and R' are alkyl groups.

(i) State the types of reaction involved in **reactions 1** and **2**.

(ii) Compound **X**, $C_3H_6O_2$ reacts with both sodium and Tollens' reagent. On treatment with hot acidified potassium dichromate(VI), **X** forms **Y**, $C_3H_4O_3$.

Deduce the structures of **X** and **Y**, giving your reasoning.

(iii) Treatment of **Y** with hydrazine forms a compound **Z**, $C_3H_{10}O_2N_4$.

Using the information provided above, suggest a structure of **Z**.

[7]

(c) Hydrogen peroxide, which is isoelectronic with hydrazine, is a common cleansing agent.

An acidified solution of hydrogen peroxide reacts with excess potassium iodide to form potassium triiodide, KI_3 as shown in the equation below.

$$H_2O_2 + 2H^+ + 3I^- \rightarrow I_3^- + 2H_2O$$

(i) State the bond angle in the H_2O_2 molecule and explain how this angle arises.

(ii) Draw the dot-and-cross diagram of the triiodide ion, I_3^- and state its shape.

(iii) Potassium triiodide dissolves readily in water. Account for its high solubility, in terms of its interaction, with water molecules.

[6]

[Total: 20]

7 (a) An unknown mass of calcium nitrite, $Ca(NO_2)_2$, was dissolved in water to form a 250 cm^3 solution. In the presence of an acid, 25.0 cm^3 of the solution required 40.00 cm^3 of 0.0200 mol dm^{-3} potassium manganate(VII) to oxidise the nitrite ion, NO_2^-, to nitrate ion, NO_3^-.

(i) Construct an equation for the reaction between acidified MnO_4^- ions and NO_2^- ions.

(ii) State the changes in oxidation states that occur for manganese and nitrogen in the reaction.

(iii) Calculate the number of moles of calcium nitrite in present in 25.0 cm^3 of the solution.

(iv) Hence, calculate the mass of calcium nitrite dissolved to form the 250 cm^3 solution.

[7]

(b) (i) State and explain how the atomic radius varies across the third period of the Periodic Table from sodium to chlorine.

(ii) By writing the full electronic configuration of a Mg^{2+} ion and a P^{3-} ion, state and explain how the ionic radius of a Mg^{2+} ion compares with that of a P^{3-} ion.

[6]

(c) Consider the following reaction scheme, starting from alkane **A**.

Alkane **A** $\longrightarrow$ **B** ($C_6H_{12}Br_2$) $\longrightarrow$ **C**(C_6H_{10})

$\downarrow$ hot acidified $KMnO_4$

$CO_2 + CH_3CO_2H + CH_3COCO_2H$

(i) Suggest reagents and conditions for the conversion of **A** to **B**.

(ii) State the type of reaction undergone when **B** is converted to **C**.

(iii) Suggest reagents and conditions for the conversion of **B** to **C.**

(iv) Suggest a structure for compound **C**, and hence deduce the structure of compound **A**.

(v) There are four possible isomers of $C_6H_{12}Br_2$ that could be converted to **C**. Draw the structures of **two** of them.

[7]

[Total: 20]

End of Paper