Name:	Index No.:	CT Group: 13

H

PIONEER JUNIOR COLLEGE

2014 JC2 PRELIMINARY EXAMINATION
HIGHER 1

CHEMISTRY **8872/02**
Paper 2

23 September 2014

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	/ 12	6	/ 20
3	/ 8	7	/ 20
4	/ 11	Penalty	s.f. / units
		TOTAL	**/ 80**

Section A (40 marks)

Answer all questions in the spaces provided.

1 This question is about Period 3 elements and their compounds.

(a) The electrical conductivity in MS m^{-1} (megasiemens per metre) at 25 ^{o}C of four consecutive elements in Period 3 are given below.

Element	**A**	**B**	**C**	**D**
Conductivity/ MS m^{-1}	22	37	1.0×10^{-3}	1.0×10^{-15}

(i) Based on the information above, identify the elements **A**, **B**, **C** and **D**.

A : _____

B: _____

C: _____

D: _____

(ii) Period 3 elements react with chlorine to form chlorides. Account for the difference in the pH values when chlorides of **B** and **D** are separately dissolved in water. Write equations to support your answer.

[6]

(b) **(i)** In the vapour phase, an equilibrium is established between aluminium chloride and its dimer as follows:

$$2AlCl_3(g) \rightleftharpoons Al_2Cl_6(g)$$

With an aid of a diagram, explain how the dimer is formed.

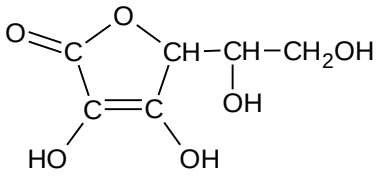
(ii) At 180 ^{o}C, aluminium chloride, Al_2Cl_6, sublimes. Explain why it sublimes at a relatively low temperature?

[3]

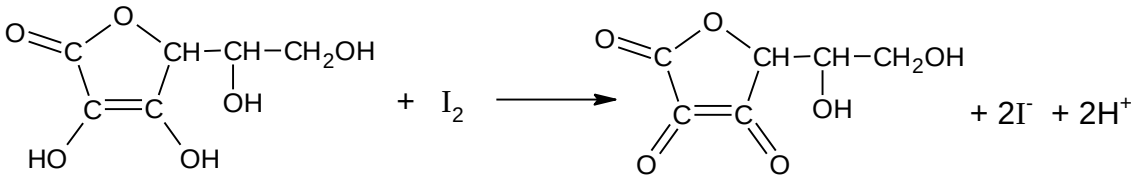
[Total: 9]

2 ***Vitamin C***, $C_6H_8O_6$, also known as ascorbic acid, is a biological antioxidant. It is commonly found in bottled fruit juices and also available in tablet form.

Vitamin C (M_r = 176) is a monobasic acid and has a **pK_a** of 4.10. It has the following structure :



(a) To determine the concentration of ascorbic acid in bottled fruit juice, a titration with iodine solution is carried out. Iodine will oxidise ascorbic acid to form dehydroascorbic acid.



ascorbic acid dehydroascorbic acid

A brand of orange juice claims to have at least 5 g of ***Vitamin C*** in every one litre bottle of its orange juice. It was found that 25.0 cm^3 of the brand's orange juice required 15.00 cm^3 of 0.0500 mol dm^{-3} iodine solution. Determine the concentration of ***Vitamin C*** in the orange juice and hence verify if the claim is likely to be true.

---

[3]

(b) When a 500 mg tablet of ***Vitamin C*** is swallowed, it dissolves in the stomach before being absorbed into the bloodstream. The stomach may be assumed to contain 1.0 dm^3 of 0.10 mol dm^{-3} hydrochloric acid.

(i) Calculate the molar concentration of the ***Vitamin C*** tablet when it is dissolved upon entering the stomach.

(ii) In the presence of the strong acid, HC*l*, calculate the concentration of the H^+ contributed by ***Vitamin C*** at equilibrium.

(iii) Hence, calculate the percentage of ***Vitamin C*** that has ionised in the stomach under these conditions.

---

[5]

(c) Blood has a pH of 7.35 and is saturated with a buffering system containing H_2CO_3 and HCO_3^-.

(i) Explain with an aid of an equation, how the buffering system minimises the changes in pH on the addition of either acid or alkali.

(ii) Explain how the extent of ionisation of ***Vitamin C*** changes as it moves from the stomach to the bloodstream.

---

[4]

[Total: 12]

3 (a) Explain what is meant by the term *rate constant.*

---

[1]

(b) The kinetics of the reaction between I^- and $S_2O_8^{2-}$ can be investigated by varying the volume of the reactants used.

$$S_2O_8^{2-}(aq) + 2I^-(aq) \rightarrow 2SO_4^{2-}(aq) + I_2(aq)$$

The two reactants are mixed in the presence of a known amount of $Na_2S_2O_3$ and a little starch. $S_2O_3^{2-}$ reacts immediately with the iodine produced.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

When the $S_2O_3^{2-}$ is used up, any further I_2 formed reacts with starch and a deep blue colour appears.

The time taken for the appearance of the deep blue colour is then determined.

Experiment	Volume used / cm^3			Time, t / s	Relative initial rate of reaction
	1.0 mol dm^{-3} KI	0.040 mol dm^{-3} $Na_2S_2O_8$	H_2O		
1	10.0	5.0	25.0	170	
2	15.0	5.0	20.0	113	
3	15.0	10.0	15.0	56.5	

(i) Given that the rate $\propto \frac{1}{t}$, complete the last column in the table, stating the units for the relative initial rate.

(ii) Determine the rate equation for the reaction between I^- and $S_2O_8^{2-}$ and state the units of the rate constant.

---

[4]

(c) With the aid of a sketch of the Boltzmann distribution, explain how the presence of a catalyst affects the rate of reaction.

[3]

[Total: 8]

4 **(a)** A monobasic organic acid, **W**, has the composition by mass: C, 40.0%; H, 6.7%; O, 53.3%.

(i) Calculate the empirical formula of the acid.

(ii) 0.90 g of **W** is exactly neutralised by 10.0 cm^3 of 1.0 mol dm^{-3} sodium hydroxide. Calculate the relative molecular mass of **W** and hence its molecular formula.

---

[3]

(b) The **W** has two isomers, **P** and **Q**. Both the isomers can be obtained by two different routes.

P is obtained by the hydrolysis of the product of the reaction between ethanal and hydrogen cyanide.

(i) Write the equation for the reaction between ethanal and hydrogen cyanide.

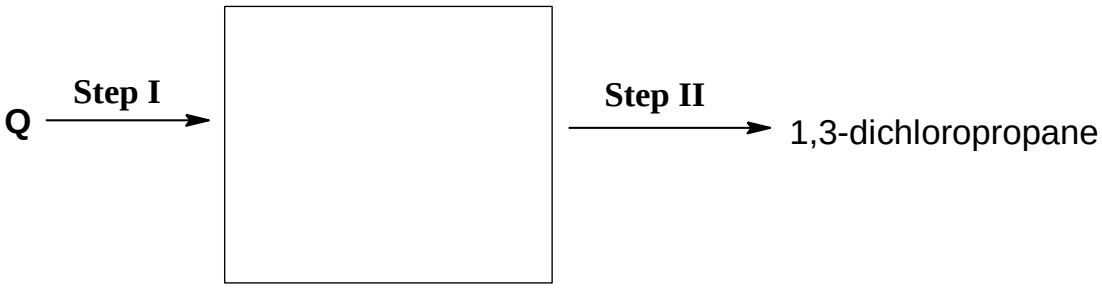
(ii) Draw the full structural formula of **P**.

[2]

(c) **Q** can be obtained by the hydrolysis of 3-chloropropanoic acid.

(i) Draw the structural formula of **Q**.

(ii) 1,3-dichloropropane can be synthesised from compound **Q** in two steps shown below.



State the reagents and conditions for Steps **I** and **II**. Draw the intermediate in the box provided above.

Step **I** : _____

Step **II :** _____

[3]

(d) Describe a simple chemical test to distinguish between **P** and **Q**.

---

[2]

(e) A cyclic di-ester, **R**, with the molecular formula of $C_6H_8O_4$ can be made from **P** when subjected to hot excess concentrated sulfuric acid.

Draw the structural formula of **R**.

[1]

[Total: 11]

Section B (40 marks)

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

5 (a) (i) Methanoic acid is a *weak acid*. What do you understand by the term in *italics*?

(ii) The dissociation constant for methanoic acid, K_a = 1.6 x 10^{-4} mol dm^{-3}. Calculate the pH of a 0.100 mol dm^{-3} solution of methanoic acid. [3]

(b) 40.0 cm^3 of 3.00 mol dm^{-3} methanoic acid, HCO_2H, is added to 60.0 cm^3 of 1.40 mol dm^{-3} potassium hydroxide in a polystyrene cup. The maximum temperature rise is recorded as 8.5 ^oC.
[specific heat capacity of the solution is 4.20 J g^{-1} K^{-1}]

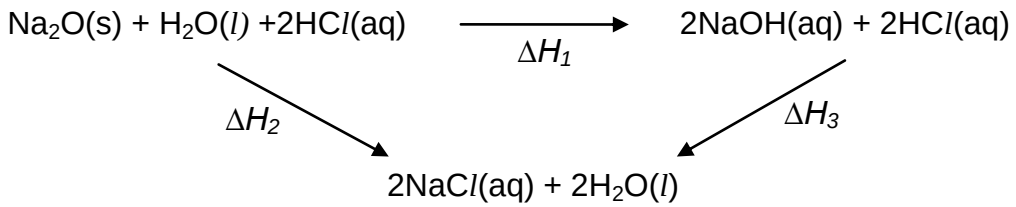
(i) Define what is meant by the *standard enthalpy change of neutralisation*.

(ii) Write a balanced chemical equation for the neutralisation of methanoic acid with potassium hydroxide.

(iii) Given that the process was 80% efficient, calculate the standard enthalpy change of neutralisation for the reaction in **(ii)**.

(iv) How would you expect the enthalpy change calculated in **(iii)** to compare with the enthalpy change of neutralisation of nitric acid with potassium hydroxide? Explain your answer. [7]

(c) Enthalpy change of reaction 1, ΔH_1, can be determined using enthalpy change of reaction 2, ΔH_2, and enthalpy change of reaction 3, ΔH_3, in the energy cycle below.



(i) ΔH_2 can be calculated from the reaction between Na_2O(s) and HC*l*(aq). When 6.2 g of Na_2O(s) is dissolved in 250 cm^3 of 1.0 mol dm^{-3} HC*l*(aq), the temperature of the solution rose by 17 ^oC. Calculate ΔH_2.

(ii) The enthalpy change of neutralisation between NaOH(aq) and HC*l*(aq) is known to be - 57.3 kJ mol^{-1}. Hence calculate ΔH_1. [3]

(d) Many fruit flavours and aromas that are used in the food industry are esters. The following is an account of the preparation of an ester, ethyl propanoate.

1. Using a measuring cylinder, place 5 cm^3 of propanoic acid and an excess of ethanol in a dry round-bottomed flask.
2. Add 0.5 cm^3 of concentrated sulfuric acid to the mixture. Add a few pieces of glass beads.
3. Fit a reflux condenser in the neck of the round-bottomed flask. Gently heat the mixture under reflux using an isomantle for about 30 minutes.
4. Cool the mixture and add 25 cm^3 of aqueous sodium carbonate to it.
5. Separate the organic layer from the aqueous layer using a separating funnel.
6. Collect the organic layer and allow it to dry in contact with anhydrous magnesium sulfate.

(i) Write an equation for the reaction between ethanol and propanoic acid

(ii) What are the two roles of concentrated sulfuric acid in the experiment?

(iii) At the end of the experiment, only about 20% of the propanoic acid has reacted. Explain why this is so?

(iv) Suggest two reasons why ethanol, instead of propanoic acid, is added in excess.

(v) Why is aqueous sodium carbonate added in step 4?

(vi) Write an equation to show the hydrolysis of ethyl propanoate using aqueous sodium hydroxide. [7]

[Total: 20]

6 (a) Explain the following observations.

(i) I_2 is sparingly soluble in water but dissolves readily in tetrachloromethane.

(ii) The boiling points of the hydrogen halides show a trend. [4]

compound	boiling point/ ^oC
HC*l*	-84.2
HBr	-67.1
HI	-35.1

(b) Draw 'dot-and-cross' diagrams to show the bonding in BrF_3 and IF_5 and state their shapes. [3]

(c) Hydrogen iodide can be made by heating together hydrogen gas and iodine vapour. The reaction takes place slowly and does not go to completion.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \quad \Delta H = -ve$$

(i) Write an expression for K_c and state its units.

(ii) State and explain how the position of equilibrium might change if the above reaction is subjected to

I: increasing the pressure.
II: decreasing the temperature.

(iii) A mixture of 0.20 mol of hydrogen and 0.20 mol of iodine was placed in a 1 dm^3 flask and allowed to reach equilibrium at 650 K.

Calculate the amount, in moles, of each substance present in the equilibrium mixture at 650 K.

The numerical value of the equilibrium constant K_c at 650 K is 59.

[7]

(d) Compare and explain, the acidity of 2-chlorobutanoic acid and 2-bromobutanoic acid. [2]

(e) The blood plasma and urine of diabetes patients can contain large amounts of 'ketone bodies'. These include propanone, 3-oxobutanoic acid and 3-hydroxybutanoic acid.

CH_3COCH_3	$CH_3COCH_2CO_2H$	$CH_3CH(OH)CH_2CO_2H$
propanone	3-oxobutanoic acid	3-hydroxybutanoic acid

Describe a simple chemical test to distinguish 3-oxobutanoic acid from

(i) propanone,

(ii) 3-hydroxybutanoic acid

[4]

[Total: 20]

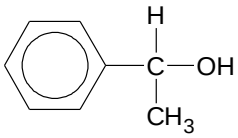
7 (a) Describe the relative masses and relative charges of the three sub-atomic particles within an atom. [2]

(b) Predict with reasons, how the radius of
(i) the fluoride ion, F^-;
(ii) the magnesium atom, Mg
compared with neon atom. [4]

(c) **(i)** Describe what you would see when sodium and sulfur are separately burnt in oxygen. Write equations for the reactions that occur.

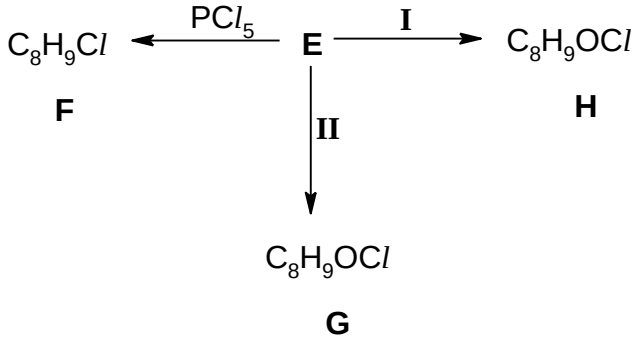
(ii) The oxides of sodium and sulfur resulting from the reactions in **(c)(i)** both react with water. Write equations for these two reactions and describe the effect of the resulting solutions on Universal Indicator solution. [4]

(d) 1-phenylethanol, **E**, is an aromatic compound and its structure is shown below.



E

Depending on the reagents and conditions, compound **E** can react to form three compounds **F**, **G** and **H**.



(i) Suggest a structural formula for compound **F**.

(ii) When reacted with hot aqueous silver nitrate, compound **H** produces a white precipitate but compound **G** does not. Compound **H** reacts with NaOH(aq) to give **J**, $C_8H_{10}O_2$ which immediately loses water to give **K**, C_8H_8O. Compound **K** reacts with 2,4-dinitrophenylhydrazine and with alkaline aqueous iodine but not with Fehling's solution.
Identify and draw the structural formulae of compounds **G**, **H**, **J** and **K**. Explain the chemistry of the reactions involved.

(iii) Suggest the reagents and conditions for reaction **I** and **II**. [10]

[Total: 20]

End of Paper