

**Chemistry**  
**Standard level**  
**Paper 2**

Friday 13 November 2015 (afternoon)

Candidate session number

1 hour 15 minutes

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**Instructions to candidates**

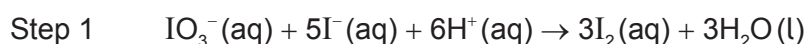
- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer one question.
- Write your answers in the boxes provided.
- A calculator is required for this paper.
- A clean copy of the **chemistry data booklet** is required for this paper.
- The maximum mark for this examination paper is **[50 marks]**.



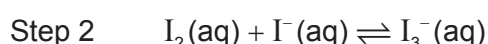
## Section A

Answer **all** questions. Write your answers in the boxes provided.

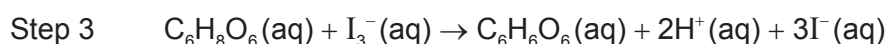
1. A student used the technique of titration to determine the concentration of ascorbic acid ( $C_6H_8O_6$ ) in a sample of orange juice. Excess potassium iodide,  $KI(aq)$ , was added to acidified orange juice. The resulting solution was titrated with potassium iodate,  $KIO_3(aq)$ , in the presence of starch as an indicator. The end-point of the titration was shown by a blue-black colour.



Iodine is only slightly soluble in water; but in the presence of excess iodide ions,  $I^-(aq)$ , it forms the soluble tri-iodide ion,  $I_3^-(aq)$ .



Ascorbic acid reacts with tri-iodide ions as follows.



- (a) (i) Deduce the changes in oxidation number of iodine in step 1. [2]

$IO_3^-$  to  $I_2$ :

.....

$I^-$  to  $I_2$ :

.....

- (ii) Identify the oxidizing **and** reducing agents in step 1. [1]

Oxidizing agent:

.....

Reducing agent:

.....

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**(Question 1 continued)**

- (b) The concentration of  $\text{KIO}_3$  used in the titration was  $2.00 \times 10^{-3} \text{ mol dm}^{-3}$ .  
The titration produced the following results.

	<b>Titration 1</b>	<b>Titration 2</b>	<b>Titration 3</b>
Final volume of $\text{KIO}_3 (\pm 0.05 \text{ cm}^3)$	7.10	14.40	21.60
Initial volume of $\text{KIO}_3 (\pm 0.05 \text{ cm}^3)$	0.00	7.10	14.40
Volume added of $\text{KIO}_3 (\pm 0.10 \text{ cm}^3)$	7.10	7.30	7.20
Mean volume added of $\text{KIO}_3 (\pm 0.10 \text{ cm}^3)$	7.20		

- (i) Calculate the percentage uncertainty associated with the mean volume of  $\text{KIO}_3(\text{aq})$ .

[1]

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- (ii) The colour of orange juice interfered with the blue-black colour at the equivalence point. State the name of this type of error **and** suggest how this can be minimized.

[2]

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- (iii) Determine the amount, in mol, of  $\text{KIO}_3(\text{aq})$ , in the mean volume.

[1]

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**(This question continues on the following page)**



**(Question 1 continued)**

- (c) Determine the amount, in mol, of ascorbic acid,  $C_6H_8O_6(aq)$ , in the sample of acidified orange juice. [2]

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- (d) Calculate the mass, in g, of ascorbic acid,  $C_6H_8O_6(aq)$ , present in the sample of acidified orange juice. [1]

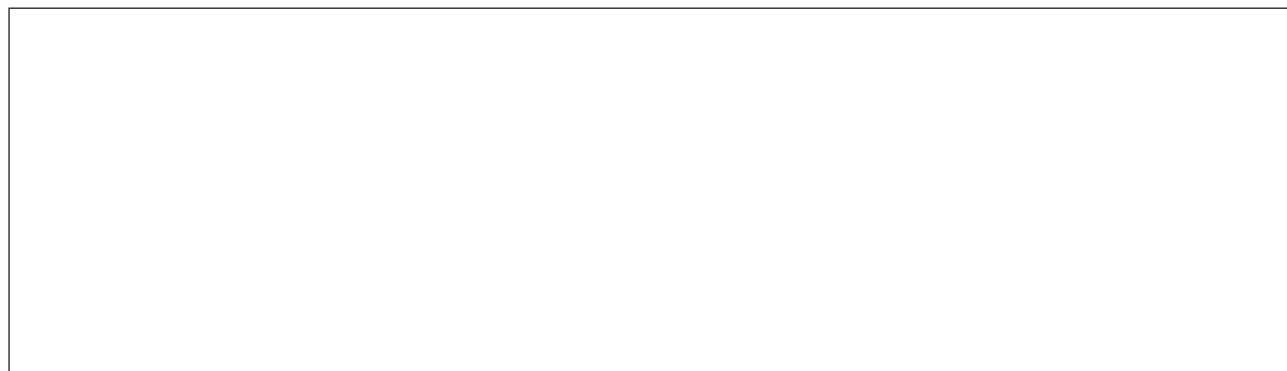
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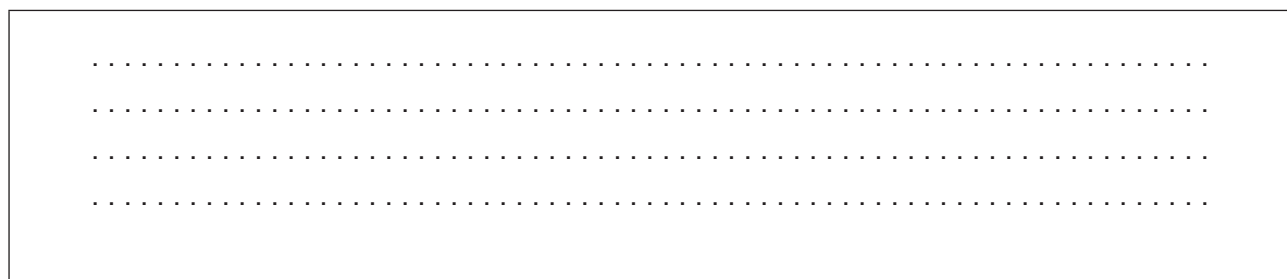
2. (a) Draw the Lewis (electron dot) structures of oxygen,  $O_2$ , ozone,  $O_3$ , and hydrogen peroxide,  $H_2O_2$ .

[3]



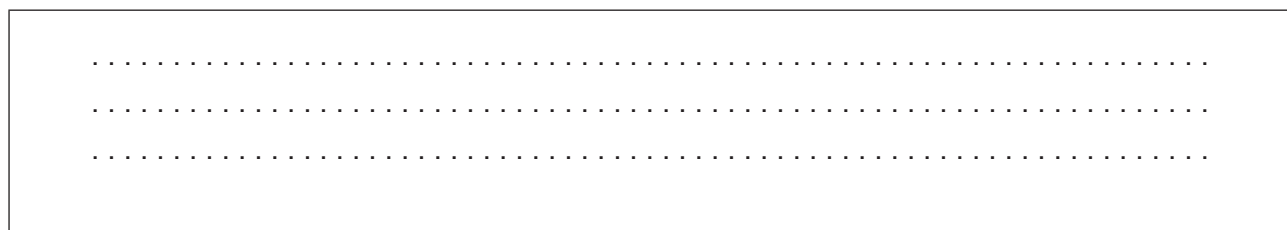
- (b) Deduce, giving a reason, the relative lengths of the oxygen to oxygen bonds in oxygen and hydrogen peroxide.

[1]



- (c) Predict, with a reason, the O–O–O bond angle in  $O_3$ .

[2]



3. Propane,  $C_3H_8(g)$ , undergoes complete combustion to form carbon dioxide,  $CO_2(g)$ , and water,  $H_2O(g)$ .

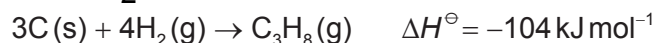
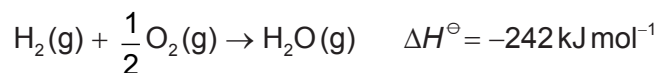
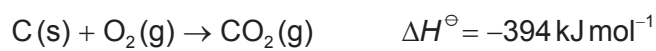
(a) State an equation for the complete combustion of propane,  $C_3H_8(g)$ . [1]

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(b) Calculate the standard enthalpy change for the reaction in part (a) using bond enthalpy values given in table 10 of the data booklet. [3]

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(c) Determine, using Hess's law, the enthalpy change,  $\Delta H^\ominus$ , in  $\text{kJ mol}^{-1}$ , for the complete combustion of propane by using the following data. [4]



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**(Question 3 continued)**

- (d) Suggest, with a reason, why the values obtained in parts (b) and (c) are different. [1]

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4. (a) (i) Define the term electronegativity. [1]

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- (ii) Suggest why the noble gases are generally not assigned electronegativity values. [1]

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- (b) Explain why the melting points of the group 1 metals (Li → Cs) decrease down the group whereas the melting points of the group 7 elements (F → I) increase down the group. [3]

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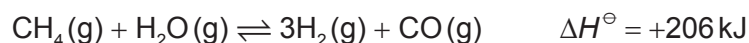
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## Section B

Answer **one** question. Write your answers in the boxes provided.

5. (a) The following reaction is used in industry to obtain hydrogen from natural gas by partial oxidation with steam.



- (i) Describe the effect, if any, of each of the following changes on the equilibrium amount of hydrogen, giving a reason in each case. [4]

Increasing the pressure, at constant temperature:

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Increasing the temperature, at constant pressure:

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- (ii) Identify which of the changes in part (a) (i) will affect the value of  $K_c$  and whether the value will increase or decrease. [1]

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- (iii) Discuss the effects of adding a solid catalyst to the mixture of methane and steam, at constant pressure and temperature. [3]

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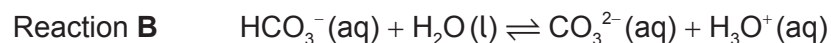
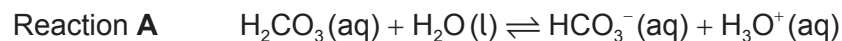
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**(Question 5 continued)**

(b) The equations of two acid-base reactions are given below.



(i) Explain whether  $\text{HCO}_3^-(\text{aq})$  behaves as an acid or a base in each of the reactions **A** and **B**.

[2]

Reaction **A**:

.....  
 .....

Reaction **B**:

.....  
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(ii) Deduce **two** conjugate acid-base pairs from reactions **A** and **B**.

[2]

	Acid	Base
<b>Conjugate acid-base pair 1</b>	.....	.....
<b>Conjugate acid-base pair 2</b>	.....	.....

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**(Question 5 continued)**

(c) Nitric acid,  $\text{HNO}_3$ , and nitrous acid,  $\text{HNO}_2$ , are described as strong and weak acids respectively.

(i) Distinguish between *strong* and *weak* acids.

[1]

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(ii) A 1.00g sample of solid magnesium carbonate,  $\text{MgCO}_3$ , is added to separate solutions of  $\text{HNO}_3$  and  $\text{HNO}_2$  of the same concentration and temperature. State **one** similarity and **one** difference in the observations made in these reactions.

[2]

Similarity:  
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Difference:  
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(iii) A solution of  $\text{HNO}_3$  has a pH of 1, while a solution of  $\text{HNO}_2$  has a pH of 5. Determine the ratio of the hydrogen ion concentration in  $\text{HNO}_3$ : $\text{HNO}_2$ .

[1]

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(Question 5 continued)

- (d) (i) State the acid-base character of the oxides of the period 3 elements Na to Ar. [2]

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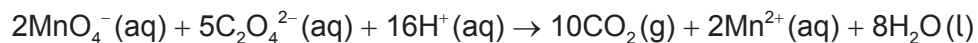
- (ii) State balanced equations to illustrate the acid-base character of sodium oxide and sulfur trioxide. [2]

Sodium oxide:  
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Sulfur trioxide:  
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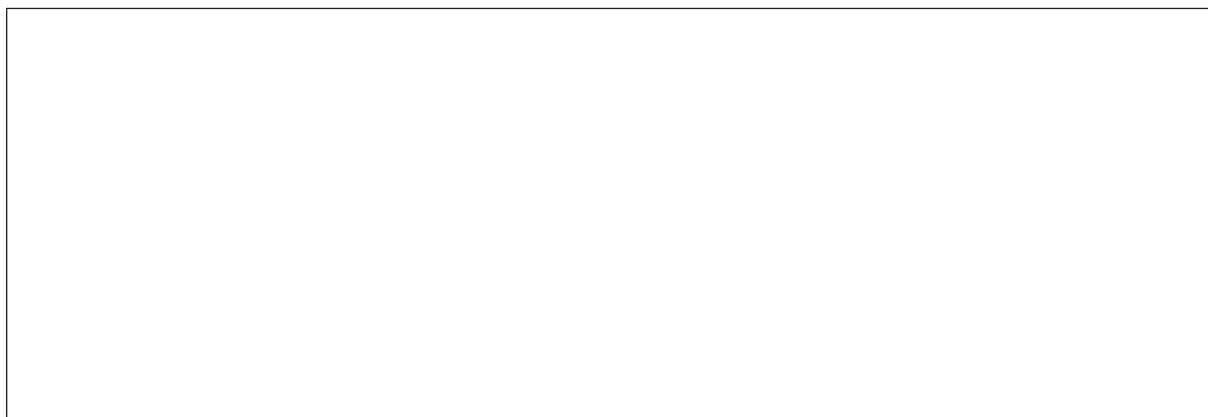
6. (a) A purple solution of potassium manganate(VII),  $\text{KMnO}_4$ , reacts with ethanedioate ions according to the following equation.



- (i) Outline an experimental procedure which may be used to measure the rate of this reaction. [3]

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- (ii) Sketch a graph to show the results of the experimental procedure outlined in (a) (i). [2]



- (iii) Outline how the rate of reaction at a particular time could be determined from the graph. [1]

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**(Question 6 continued)**

- (iv) Discuss, in terms of collision theory, the effect of increasing temperature on the rate of this reaction. [3]

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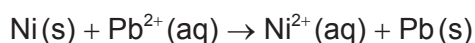
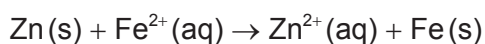
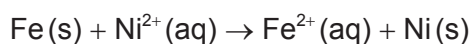
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- (b) Consider the following spontaneous reactions.



- (i) Deduce the order of **increasing** reactivity of the metals based on the reactions above. [2]

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- (ii) Identify the strongest oxidizing agent in the reactions above. [1]

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**(Question 6 continued)**

- (c) Draw a diagram of an electrolytic cell for the electrolysis of molten nickel(II) bromide,  $\text{NiBr}_2(\text{l})$ . Include the direction of the electron flow, the polarity of electrodes and the half-equations at each electrode. [4]

Negative electrode (cathode):  
.....  
Positive electrode (anode):  
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- (d) (i) In the operation of a mass spectrometer, the first stage is vaporization and the last is detection. State the names of the other three stages and outline what happens in each one. [3]

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- (ii) Suggest why a very low pressure is maintained inside the mass spectrometer. [1]

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7. (a) A 0.842g sample of a liquid halogenoalkane, RBr(l), was heated under reflux with  $1.35 \times 10^{-2}$  mol of aqueous sodium hydroxide, NaOH(aq). After cooling the mixture, the excess NaOH was titrated with hydrochloric acid, HCl(aq), and required  $7.36 \times 10^{-3}$  mol of the acid.

- (i) State the equation for the substitution reaction of the halogenoalkane with sodium hydroxide. [1]

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- (ii) Calculate the amount, in mol, of sodium hydroxide that reacted with the halogenoalkane. [1]

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- (iii) Calculate the molar mass of the halogenoalkane. [1]

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- (iv) Given that each molecule of the halogenoalkane contains one bromine atom, determine its molecular formula. [1]

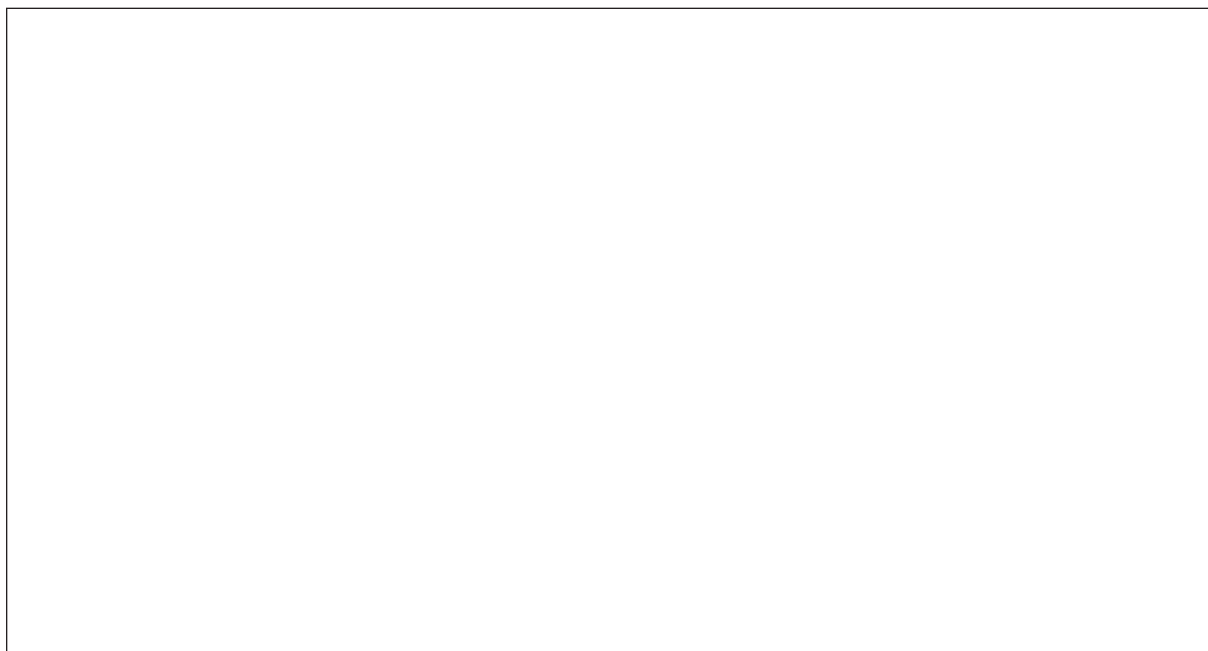
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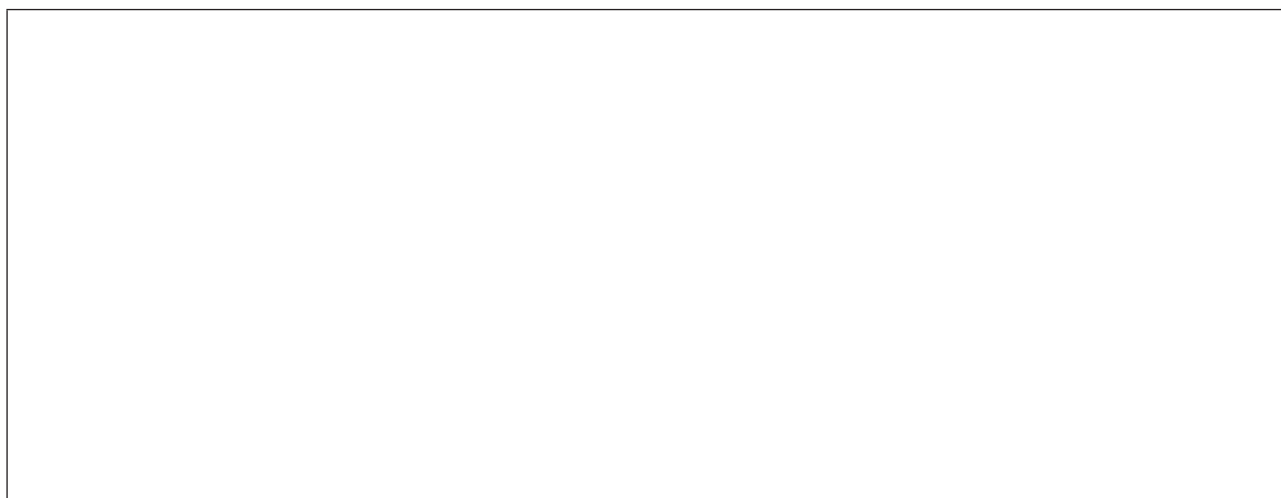
**(Question 7 continued)**

- (v) Deduce the structural formulas of **four** structural isomers of the halogenoalkane based on the molecular formula **and** label each isomer as primary, secondary or tertiary. (If you have not been able to determine the molecular formula in part (a) (iv), use  $C_5H_{11}Br$  to deduce the four structural isomers.) [4]



- (b) The reaction between a primary halogenoalkane drawn in part (a) (v) and sodium hydroxide follows a  $S_N2$  mechanism.

Explain the mechanism of the reaction using curly arrows to represent the movement of electron pairs. [4]



**(This question continues on the following page)**





## (Question 7 continued)

- (c) (i) List the following compounds in order of **increasing** boiling point:  
 $\text{CH}_3\text{CHO}$ ,  $\text{CH}_3\text{CH}_2\text{CH}_3$ ,  $\text{CH}_3\text{COOH}$ ,  $\text{CH}_3\text{CH}_2\text{OH}$ .

[2]

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- (ii) Explain the order of boiling points in the compounds listed in part (c) (i), in terms of intermolecular forces.

[4]

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- (iii)  $\text{CH}_3\text{CH}_2\text{OH}$  can be oxidized in aqueous solution by acidified potassium dichromate(VI) by heating under reflux. Deduce the structural formula of the final product formed **and** state the colour change during the oxidation process.

[2]

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