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## DUNMAN HIGH SCHOOL Promotional Examination Year 5

CHEMISTRY

(Higher 2)

Paper 1 Multiple Choice

9647/01

26 September 2014

30 minutes

Additional Materials:      Optical Mark Sheet  
   Data Booklet

### INSTRUCTIONS TO CANDIDATES

- 1 Write your **name**, **index number** and **class** on this question paper.
- 2 There are **twenty** questions in this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.  
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Optical Mark Sheet.
- 3 Each correct answer will score one mark. A mark will not be deducted for wrong answer.
- 4 Any rough working should be done in this booklet.
- 5 You may use a calculator.

### Section A

For each question, there are four possible answers **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

- 1 A 3.78 g sample of citric acid ( $\text{C}_6\text{H}_8\text{O}_7$ ,  $M_r = 192$ ) was dissolved in a  $100 \text{ cm}^3$  of  $1.0 \text{ mol dm}^{-3}$  sodium hydroxide. The resulting solution was made up to  $250 \text{ cm}^3$  using deionised water. It was found that  $25.0 \text{ cm}^3$  of this solution required  $20.00 \text{ cm}^3$  of  $0.100 \text{ mol dm}^{-3}$  sulfuric acid for complete neutralisation.

What is the amount of sodium hydroxide required to react with 1 mol of citric acid?

- A** 1                      **B** 2                      **C** 3                      **D** 4

- 2 A student has mixed up the data containing second ionisation energies (I.E.) of the following Period 5 and Period 6 elements: Rb, Te, I and Cs.

They are labelled **W**, **X**, **Y** and **Z** in the table below.

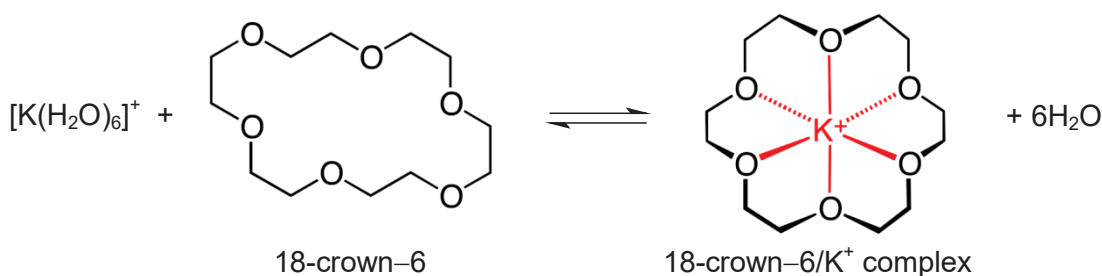
What is the identity of element **Y**?

Unknown Element	<b>W</b>	<b>X</b>	<b>Y</b>	<b>Z</b>
Second I.E.	1470	1846	2234	2633

- A** Rb                      **B** Te                      **C** I                      **D** Cs

- 3 Crown ethers are a class of cyclic organic compounds which can bind to metal cations, forming complexes.

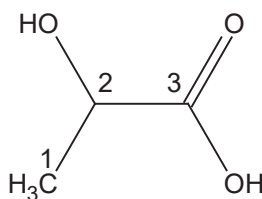
An example is seen below whereby the crown ether, 18-crown-6, binds to  $[\text{K}(\text{H}_2\text{O})_6]^+$  forming the 18-crown-6/ $\text{K}^+$  complex.



Which of the following statements is **incorrect**?

- A** Dative bonds are formed between  $\text{K}^+$  and 18-crown-6 in this reaction.
- B** Based on VSEPR theory,  $\text{O}-\text{K}^+-\text{O}$  in the complex has a bond angle of  $90^\circ$ .
- C** The 18-crown-6/ $\text{K}^+$  complex is more soluble in non-polar solvents than  $[\text{K}(\text{H}_2\text{O})_6]^+$ .
- D**  $\text{K}^+$  uses its 4s and 4p atomic orbitals for bonding with 18-crown-6 in this reaction.

- 4 In lactic acid, it was found that the C2–C3 has shorter bond length than C1–C2.



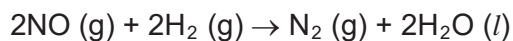
Which of the following statements best account for the shorter bond length in C2–C3?

- A** It is an  $sp^2-sp^3$  overlap.
- B** The electrons in C2 are attracted towards the C3=O group.
- C** The C2–C3 bonding is pulled shorter by a p–p ( $\pi$ -bond) overlap.
- D** It has two OH substituent groups compared to only one OH substituent group in C1–C2, causing greater electron density to be withdrawn from its bonding electrons.

- 5** Which of these compounds possess 1  $\sigma$  and 1  $\pi$  bonds?

- A**     $\text{C}_2\text{H}_2$                       **B**     $\text{CaN}_2$
- C**     $\text{HCIO}$                          **D**     $\text{KHF}_2$

- 6** The reaction:



has a rate equation,  $\text{Rate} = k[\text{NO}][\text{H}_2]^2$ . Determine the values of **x** and **y** in the table below.

[NO] / mol dm <sup>-3</sup>	[H <sub>2</sub> ] / mol dm <sup>-3</sup>	<i>t</i> <sub>1/2</sub> with respect to NO/s
0.0150	1.00	7.2
0.0300	1.00	<b>x</b>
0.0150	2.00	<b>y</b>

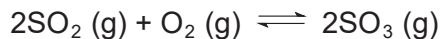
- |          | $x$ | $y$ |
|----------|-----|-----|
| <b>A</b> | 3.6 | 1.8 |
| <b>B</b> | 3.6 | 3.6 |
| <b>C</b> | 7.2 | 1.8 |
| <b>D</b> | 7.2 | 3.6 |

- 7 Use of the Data Booklet is required for this question.

Enthalpy change of formation of methanol,  $\text{CH}_3\text{OH}$  (g), is  $-204 \text{ kJ mol}^{-1}$ .

What is the standard enthalpy change of atomisation of carbon?

- A**  $+726 \text{ kJ mol}^{-1}$                       **B**  $-1134 \text{ kJ mol}^{-1}$   
**C**  $+1846 \text{ kJ mol}^{-1}$                       **D**  $-2254 \text{ kJ mol}^{-1}$
- 8 For a given mass of an ideal gas, which of the following graphs display a different shape from the rest?
- A** PV against P (at constant T)  
**B**  $\frac{V}{T}$  against T (at constant P)  
**C** PV against V (at constant T)  
**D**  $\frac{1}{\text{density}}$  against T (at constant P)
- 9 The chemical equation for the Contact process used in industrial production of sulfur trioxide is given below:



Sulfur dioxide and oxygen gases were fed in a 2:1 volume ratio into a reaction vessel at a constant pressure of 0.5 atm. At equilibrium, the percentage conversion of sulfur dioxide was 33%.

What is the partial pressure of sulfur trioxide at equilibrium in atm?

- A** 0.11                      **B** 0.17                      **C** 0.22                      **D** 0.34
- 10 A complex reaction ( $2\text{A} + \text{B}^- + \text{C}^+ \rightarrow \text{F}$ ) was found to have the following reaction mechanism:

Step No.	Mechanism
I	$\text{A} \rightleftharpoons \text{B}^- + \text{C}^+$
II	$\text{A} + \text{B}^- \rightarrow \text{D}^-$
III	$2\text{C}^+ + \text{D}^- \rightarrow \text{E}^+$
IV	$\text{E}^+ + \text{B}^- \rightleftharpoons \text{F}$

Which of the following step number is most likely to be the rate determining step?

- A** I                      **B** II                      **C** III                      **D** IV

- 11 When pure ice melts,  $6.01 \text{ kJ mol}^{-1}$  of heat enthalpy is exchanged with its surroundings.

What is the change in entropy when 126 g of ice melts at  $0^\circ\text{C}$ ?

- A  $-22.0 \text{ J K}^{-1}$                       B  $+154 \text{ J K}^{-1}$   
C  $-154 \text{ J K}^{-1}$                       D  $+22.0 \text{ J K}^{-1}$

- 12  $100 \text{ cm}^3$  of  $0.200 \text{ mol dm}^{-3}$  hydrofluoric acid ( $\text{p}K_{\text{a}} = 3.15$ ) is added to  $50 \text{ cm}^3$  of  $0.200 \text{ mol dm}^{-3}$  sodium hydroxide.

What is the pH of the resulting solution?

- A 1.92                      B 2.16                      C 2.72                      D 3.15

- 13 The oxidation number of the carbon atom in methanol,  $\text{CH}_3\text{OH}$ , is  $-2$ . Methanol can be oxidised to a carbon-containing compound, Y, in which the oxidation state of the carbon atom is 0.

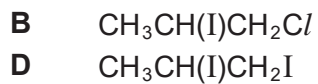
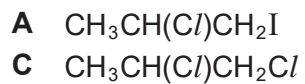
Which of the following is a possible structure for compound Y?

- A  $\begin{array}{c} \text{OH} \\ | \\ \text{HO}-\text{C}=\text{O} \end{array}$                       B  $\begin{array}{c} \text{OH} \\ | \\ \text{H}-\text{C}=\text{O} \end{array}$   
C  $\text{O}=\text{C}=\text{O}$                       D  $\begin{array}{c} \text{H} \\ | \\ \text{H}-\text{C}=\text{O} \end{array}$

- 14 Which of the following alcohols, upon dehydration, yields alkenes with the largest number of isomers?

- A  $\begin{array}{c} \text{CH}_3\text{CH}_2\text{CH}_2\text{CHCH}_3 \\ | \\ \text{OH} \end{array}$   
B  $\begin{array}{c} \text{CH}_3\text{CH}_2\text{CHCH}_2\text{CH}_3 \\ | \\ \text{OH} \end{array}$   
C  $\begin{array}{c} \text{CH}_3\text{CH}_2\text{CHCH}_2\text{OH} \\ | \\ \text{CH}_3 \end{array}$   
D  $\begin{array}{c} \text{CH}_3\text{CH}_2\text{CHCH}_2\text{CH}_2\text{OH} \\ | \\ \text{CH}_3 \end{array}$

- 15** Hydrogen iodide undergoes reaction with propene, forming 2-iodopropane. When iodine monochloride,  $ICl$ , is reacted with propene, a similar reaction occurs. What is the most likely final product?



## Section B

For each question in this section, one or more of the three numbered statements **1** to **3** may be correct.

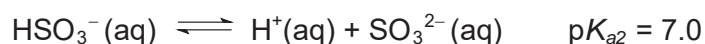
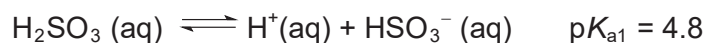
Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements which you consider to be correct).

The responses **A** to **D** should be selected on the basis of

<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
<b>1, 2 and 3</b> are correct	<b>1 and 2 only</b> are correct	<b>2 and 3 only</b> are correct	<b>1 only</b> is correct

No other combination of statements is used as a correct response.

- 16** Sulfurous acid dissolves in water to establish the following equilibria:



Which of the following statements correctly represent the relative concentrations of each species at equilibrium?

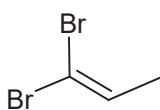
- 1**  $[\text{H}^+] > [\text{HSO}_3^-]$
- 2**  $[\text{H}_2\text{SO}_3] > [\text{HSO}_3^-]$
- 3**  $[\text{SO}_3^{2-}] > [\text{HSO}_3^-]$

- 17** Which of the following organic molecules do not possess stereoisomers?

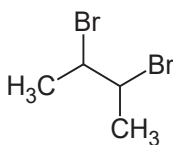
**1**



**2**



**3**



The responses **A** to **D** should be selected on the basis of

<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
<b>1, 2 and 3</b> are correct	<b>1 and 2 only</b> are correct	<b>2 and 3 only</b> are correct	<b>1 only</b> is correct

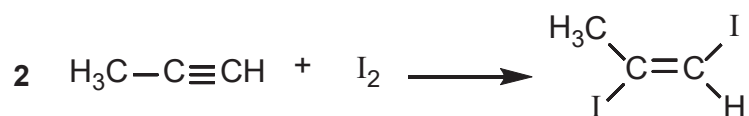
No other combination of statements is used as a correct response.

- 18** Reaction of ethene with chlorine in the presence of aqueous potassium bromide gives a mixture of products.

Which of the following compounds exist in the product mixture?

- 1**  $\text{CH}_2\text{BrCH}_2\text{OH}$
- 2**  $\text{CH}_2\text{Cl}/\text{CH}_2\text{Cl}$
- 3**  $\text{CH}_2\text{Cl}/\text{CH}_2\text{OH}$

- 19** Which of the following reactions are examples of electrophilic addition?



- 20** Three  $100 \text{ cm}^3$  water samples (labeled **A**, **B** and **C**) are each contaminated with varying concentrations of a contaminants, as shown in the table below.

Label	Contaminant	Concentration ( $\text{mol dm}^{-3}$ )
<b>A</b>	$\text{Ba}(\text{NO}_3)_2$	$3 \times 10^{-3}$
<b>B</b>	$\text{BaF}_2$	$5 \times 10^{-3}$
<b>C</b>	$\text{NaF}$	1

Which of the following solutions will precipitate  $\text{BaF}_2$  ( $K_{\text{sp}} = 1.8 \times 10^{-7}$ ) when they are mixed together?

- 1** **A** with **B**
- 2** **A** with **C**
- 3** **B** with **C**



**2014 Year 5 H2 Chemistry Promo P1 Answer Key**

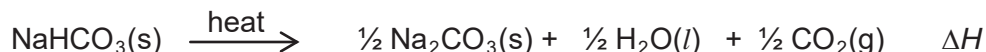
<b>Question</b>		<b>Question</b>	
1	<b>C</b>	11	<b>B</b>
2	<b>D</b>	12	<b>D</b>
3	<b>D</b>	13	<b>D</b>
4	<b>A</b>	14	<b>A</b>
5	<b>B</b>	15	<b>A</b>
6	<b>C</b>	16	<b>B</b>
7	<b>A</b>	17	<b>B</b>
8	<b>D</b>	18	<b>C</b>
9	<b>B</b>	19	<b>B</b>
10	<b>C</b>	20	<b>C</b>

## Section A

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

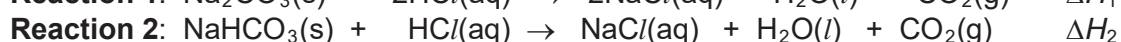
### 1 Planning

When sodium hydrogencarbonate is heated, it decomposes to form sodium carbonate according to the reaction:



This enthalpy change during this reaction,  $\Delta H$  is difficult to measure directly, so an indirect method is used.

By determining the enthalpy change for **Reaction 1** and **Reaction 2** below, it is possible to obtain indirectly the enthalpy change for the decomposition of sodium hydrogencarbonate.



You are provided with 5 mol dm<sup>-3</sup> hydrochloric acid, solid sodium carbonate and solid sodium hydrogencarbonate. *Experiment 1* was carried out to determine  $\Delta H_1$ . A known mass of sodium carbonate was reacted with 50.0 cm<sup>3</sup> of 5 mol dm<sup>-3</sup> hydrochloric acid (excess). The reaction mixture was stirred and the highest temperature reached is recorded.

4.3 J is required to raise the temperature of 1.0 cm<sup>3</sup> of any solution by 1 °C.

- (a) Given the following data, show how the enthalpy change of reaction between solid Na<sub>2</sub>CO<sub>3</sub> and hydrochloric acid,  $\Delta H_1$ , can be determined.

	Data
Mass of weighing bottle and solid sample / g	a
Mass of weighing bottle and residual solid / g	b
Initial temperature of hydrochloric acid / °C	T <sub>1</sub>
Final constant temperature of hydrochloric acid / °C	T <sub>2</sub> where T <sub>2</sub> > T <sub>1</sub>

[1]

- (b) Construct a suitable energy cycle and use it to show how  $\Delta H$  can be calculated from  $\Delta H_1$  and  $\Delta H_2$ .

[2]

- (c) *Experiment 2* is carried out to determine  $\Delta H_2$ . The procedure for *Experiment 1* is repeated, using solid sodium hydrogencarbonate in place of solid sodium carbonate.

In a preliminary investigation, the enthalpy change for **Reaction 2** is found to be approximately  $+28.5 \text{ kJ mol}^{-1}$ .

Suggest a suitable mass of solid sodium hydrogencarbonate that could be used for *Experiment 2*. Justify your choice with relevant calculations, stating any assumptions made.

You may assume a temperature change of  $5^\circ\text{C}$ .

[2]

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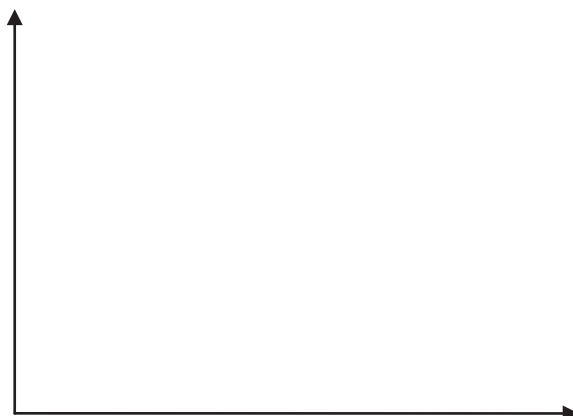
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- include appropriate apparatus, masses and volumes of reagents;
- allow for the plotting of a suitable graph to correct for surrounding heat transfer;
- draw table(s) with headings to show the measurements you would make.

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

- (e) Draw a sketch of the graph that you would expect to obtain in the experiment. Indicate clearly on the graph the initial and final temperature that you would read.

[1]



- (f) Suggest and state a reason for a safety precaution for the experiments.

[1]

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[Total: 12]

- 2 Four samples of known masses of ethanoic acid were placed in separate closed vessels. The temperature in all the vessels was 120 °C. The results were as shown.

Sample	Density / g m <sup>-3</sup>	Pressure / atm	average M <sub>r</sub>
1	1.25 x 10 <sup>5</sup>	6.83	60
2	9.49 x 10 <sup>5</sup>	31.00	<i>x</i>
3	1.88 x 10 <sup>4</sup>	51.69	119
4	3.17 x 10 <sup>4</sup>	86.13	120

- (a) (i) Calculate the average relative molecular mass of ethanoic acid, *x*, for sample 2.

- (ii) Explain the change in average  $M_r$  of ethanoic acid as the pressure is increased gradually.

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- (iii) Draw the structure of the predominant species of ethanoic acid at high pressures.

[5]

- (b) The label on the bottle of ethanoic acid is misplaced and the acid is mixed up with an unlabelled bottle of dilute hydrochloric acid.

A student proposes to add in  $1\text{ cm}^3$  of aqueous NaOH to  $5\text{ cm}^3$  of each acid in two separate boiling tubes. The pH of both resultant solutions is measured before and after two drops of concentrated nitric acid is added to it.

Explain qualitatively if this method works in identifying the two acids.

[3]

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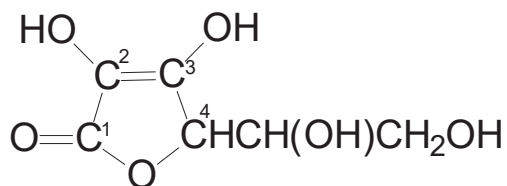
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[Total: 8]

- 3 L–ascorbic acid, also known as vitamin C, is an essential nutrient and is required for the synthesis of collagen in humans. The diagram below shows the structure of ascorbic acid:



- (a) State the hybridisation of C–4 and draw the hybrid orbitals, indicating the bond angle. Deduce the molecular shape with respect to C–4.

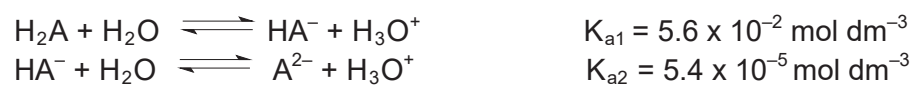
Hybridisation	Drawing of hybrid orbitals (with the bond angle indicated)	Molecular shape
_____		_____

[2]

- (b) State the total number of isomers of L–ascorbic acid.

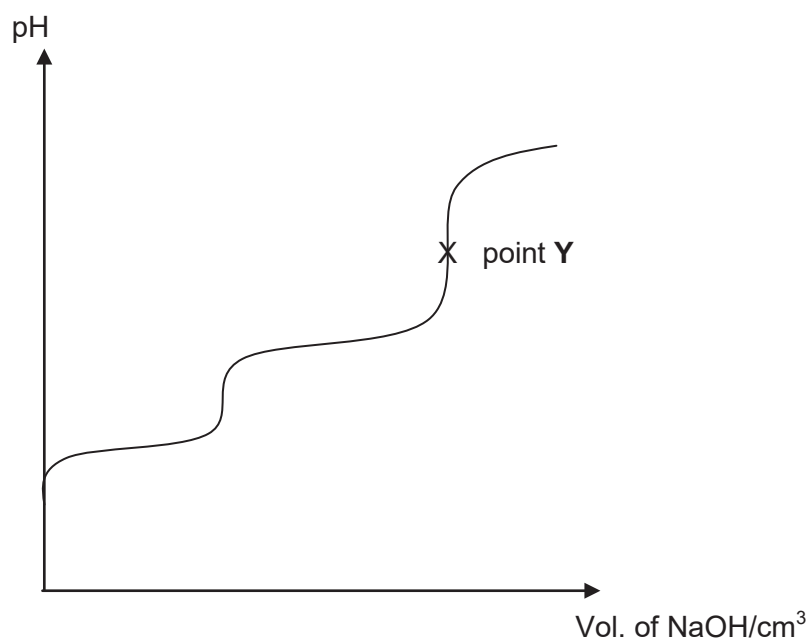
[1]

- (c) Ascorbic acid is a weak diprotic acid which can be represented as  $\text{H}_2\text{A}$ . It dissociates in water according to the following equations:



A  $10 \text{ cm}^3$  sample of  $0.100 \text{ mol dm}^{-3}$  of ascorbic acid was titrated with  $0.100 \text{ mol dm}^{-3}$  of sodium hydroxide.

The titration curve for the above titration was given below.



- (i) Explain why the value of  $K_{a1}$  is larger than  $K_{a2}$ .

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- (ii) Calculate the initial pH of ascorbic acid.



- (iii) Explain, with the aid of appropriate equation(s), if the pH at point Y is less than 7, at 7 or more than 7.

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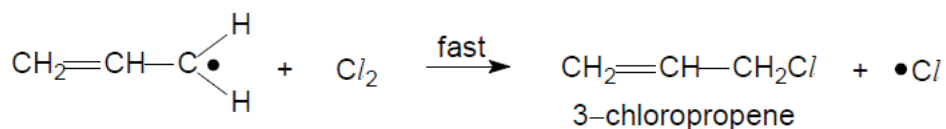
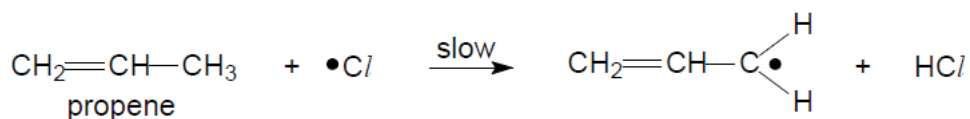
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- (iv) Calculate the pH of the solution when 45 cm<sup>3</sup> of sodium hydroxide was added to the sample.

[7]  
[Total: 10]

- 4 The Shell process involves the free radical substitution of gaseous propene to give 3-chloropropene at a high temperature of 400 °C.

- (a) The propagation steps of the free radical substitution are as follows:



- (i) Identify the catalyst involved in the propagation steps of the Shell process.

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- (ii) This process also produces small quantities of CH<sub>2</sub>CH(CH<sub>2</sub>)<sub>2</sub>CHCH<sub>2</sub>. Explain how this might arise.

[2]

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- (b) At a lower temperature, propene can react with chlorine via a different mechanism to form a product with molecular formula  $C_3H_6Cl_2$ .

Name the type of reaction and describe the mechanism for this reaction, including curly arrows showing the movement of electrons, and all relevant charges.

[3]

**Type of reaction:** \_\_\_\_\_

**Mechanism:**

- (c) Two organic compounds, **J** and **K**, both with the molecular formula  $C_4H_7Cl$ , are subjected to several chemical tests in order to elucidate their structures.

- (i) The chemical tests and the results are recorded in the table below.  
Fill in the *blanks* for the type of reaction and the deduction of structure based on observation of each test result.

Reagent & condition used in chemical test	Type of Reaction	Compound	Observation	Deduction(s)
Cold alkaline $KMnO_4$ (aq)		<b>J</b>	Decolourisation of cold dilute $KMnO_4$ occurred.	
		<b>K</b>	No decolourisation observed.	
Hot acidified $KMnO_4$ (aq)		<b>J</b>	Effervescence of gas. Decolourisation of hot acidified $KMnO_4$ occurred.	
		<b>K</b>	No decolourisation or gas production observed.	

- (ii) Through analysis with a polarimeter, **J** was found to rotate plane polarised light at an angle of  $+34^\circ$  while no optical rotation was observed for **K**.

Deduce and draw the structures for **J** and **K**.

- (iii) Write a balanced equation for the reaction between **J** and hot acidified potassium manganate in the second test, showing the structure of the organic product formed.

[5]

[Total: 10]

## Section B

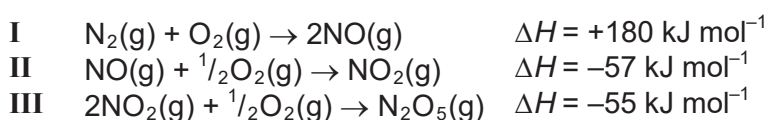
Answer **all** questions on the writing paper provided.

**1** Dinitrogen pentoxide,  $\text{N}_2\text{O}_5$ , exists as a colourless crystal that sublimes at  $47^\circ\text{C}$ . In the solid state, each formula unit of  $\text{N}_2\text{O}_5$  consist of two ions. Each ion contains only one nitrogen atom with an oxidation state of +5. In the gaseous state,  $\text{N}_2\text{O}_5$  exists as a molecule.

- (a) (i) State the formulae of the two ions in the solid state and draw the 'dot-and-cross' diagram for the anion.
- (ii) Each  $\text{N}_2\text{O}_5$  molecule consists of an N–O–N bond. Draw the Lewis structure for  $\text{N}_2\text{O}_5$  in the gaseous state and suggest the different bond angles in the molecule.

[4]

(b) Gaseous  $\text{N}_2\text{O}_5$  can be produced by the following reaction sequence in the car engine.



- (i) Suggest why reaction **I** is endothermic.
- (ii) Nitrogen dioxide is a pollutant that is often produced in car engine. Suggest how the pollutant can be removed in the car engine.
- (iii) The standard enthalpy change of formation of  $\text{N}_2\text{O}_5$  is  $-43.1 \text{ kJ mol}^{-1}$ .

By writing a balanced equation, explain what is meant by the **standard** enthalpy change of formation of  $\text{N}_2\text{O}_5$ .

- (iv) By drawing a suitable energy cycle and using the data in (b) and (b)(iii), calculate the enthalpy change of sublimation of 1 mole of  $\text{N}_2\text{O}_5$ .

[6]

(c) The gaseous dinitrogen pentoxide produced in reaction **III** in (b) can undergo decomposition to give a brown gas and a colourless gas, according to the equation:



The rate of this decomposition can be investigated by monitoring the concentration of nitrogen dioxide produced. The data shown in the table below was obtained during the decomposition of  $2.00 \text{ mol dm}^{-3}$  dinitrogen pentoxide at  $380 \text{ K}$ .

Time / min	$[\text{NO}_2] / \text{mol dm}^{-3}$
0	0
20	1.88
40	2.88
60	3.36
80	3.64
100	3.80
120	3.88

- (i) Briefly describe a method by which the rate of decomposition could be monitored.

Plot the data given in the table on Page 11 on suitable axes. Show all your workings and draw clearly any construction lines on your graph.

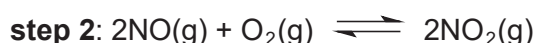
Use the graph to determine:

- (ii) the order of reaction with respect to  $\text{N}_2\text{O}_5$ ;
- (iii) and calculate a value for the rate constant. Include units in your answer.

[5]

- (d) A two-step mechanism has been proposed for this decomposition of  $\text{N}_2\text{O}_5$ :

**step 1:** \_\_\_\_\_



- (i) Write a balanced equation for **step 1** for the proposed mechanism.
- (ii) In **step 2**, the rate constant for the forward reaction and backward reaction are found to be  $2.6 \times 10^3 \text{ dm}^6 \text{ mol}^{-2} \text{ s}^{-1}$  and  $4.1 \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$  respectively at  $380^\circ\text{C}$ .

Write the expression for the equilibrium constant,  $K_c$ . Hence, calculate a value for  $K_c$ , stating its units.

- (iii) Sketch an energy profile diagram for the proposed mechanism represented by **step 1** and **step 2**. Label your diagram clearly with the reactants, products and relevant enthalpy change. Numerical values of the enthalpy changes are not required.

[5]

[Total: 20]

- 2 The solubility of solid lead iodate(V),  $\text{Pb}(\text{IO}_3)_2$ , in water is low.

The  $K_{\text{sp}}$  of lead iodate(V) could be determined through the following steps, via titrimetric analysis.

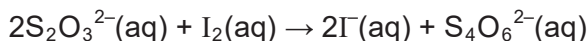
A sample of the salt is mixed with  $1 \text{ dm}^3$  water to form a mixture, where an equilibrium between the solid salt and its aqueous ions is established.



**Step 1:** The mixture is filtered and the filtrate collected for **step 2**.

**Step 2:** When excess solid KI is added to  $500 \text{ cm}^3$  of the acidified filtrate, a comproportionation reaction occurs and iodine is liberated.

**Step 3:** The liberated iodine in a  $25 \text{ cm}^3$  aliquot of the resultant solution (from **step 2**) is then titrated with  $12 \text{ cm}^3$  of  $0.001 \text{ mol dm}^{-3}$  sodium thiosulfate.



- (a) Write a balanced reduction half-equation and the overall ionic equation for the comproportionation reaction in **step 2**. [2]

- (b) The mixture *must* be filtered in **step 1** before KI is added to the filtrate collected.

- (i) Explain why it is necessary to filter the mixture before adding KI.  
(ii) Describe how the end-point of the iodine–thiosulfate titration could be determined. [4]

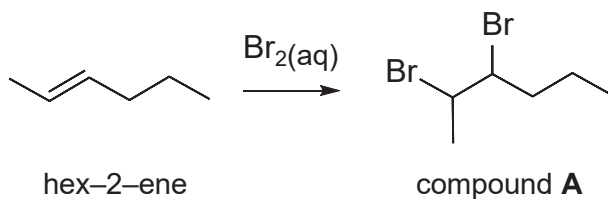
- (c) (i) Calculate the amount of iodine liberated in  $500 \text{ cm}^3$  of the acidified filtrate in **step 2**.  
(ii) Hence or otherwise, calculate the concentration of iodate(V) ions in the acidified filtrate.  
(iii) Write an expression for the solubility product of lead iodate(V) and determine its value, using your answers in (c)(ii). Include the units for your answer. [4]

- (d) The tendency for the dissolution of lead iodate(V) to reach the state of equilibrium is driven by the Gibbs free energy,  $\Delta G^\theta$  and this relationship can be defined by the following equation:

$$\Delta G^\theta = -RT \ln K_{\text{sp}}, \quad \text{where } R \text{ is the gas constant}$$

- (i) Using the above equation and your answer in (c)(iii), calculate  $\Delta H^\theta$  for the dissolution of lead iodate(V), given that  $\Delta S^\theta = +200 \text{ J K}^{-1} \text{ mol}^{-1}$ .  
(ii) Explain how the positive signs of  $\Delta H^\theta$  and  $\Delta S^\theta$  relate to the changes that occur at the molecular level for the dissolution of the salt. [4]

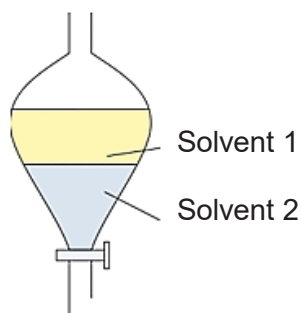
- (e) A student attempts to synthesise compound **A** from liquid hexa-2-ene. He adds aqueous bromine to hex-2-ene and stirs the mixture for some time, in the absence of light.



- (i) Explain why compound **A** will not be the major product formed and give the structure of the major product formed.
- (ii) After the synthesis, the student attempts to extract compound **A** from the reaction mixture using liquid pentane.

He adds liquid pentane into the reaction mixture and two immiscible layers are formed, after shaking the mixture thoroughly. Compound **A** will preferentially dissolve in one of the layers.

Given that the density of pentane is  $0.63 \text{ g cm}^{-3}$ , state and explain which solvent layer will have more of the dissolved compound **A**.



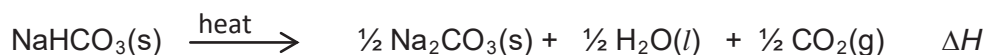
[6]

[Total: 20]

Paper 2 Section A

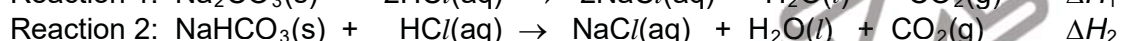
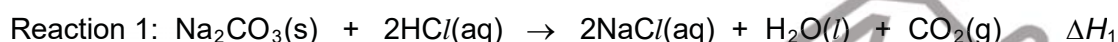
1 Planning

When sodium hydrogencarbonate is heated, it decomposes to form sodium carbonate according to the reaction:



This enthalpy change during this reaction,  $\Delta H$  is difficult to measure directly, so an indirect method is used.

By determining the enthalpy change for Reaction 1 and Reaction 2 below, it is possible to obtain indirectly the enthalpy change for the decomposition of sodium hydrogencarbonate.



You are provided with  $5 \text{ mol dm}^{-3}$  hydrochloric acid, solid sodium carbonate and solid sodium hydrogencarbonate. *Experiment 1* was carried out to determine  $\Delta H_1$ . A known mass of sodium carbonate was reacted with  $50.0 \text{ cm}^3$  of  $5 \text{ mol dm}^{-3}$  hydrochloric acid (excess). The reaction mixture was stirred and the highest temperature reached is recorded.

$4.3 \text{ J}$  is required to raise the temperature of  $1.0 \text{ cm}^3$  of any solution by  $1^\circ\text{C}$ .

- (a) Given the following data, show how the enthalpy change of reaction between solid  $\text{Na}_2\text{CO}_3$  and hydrochloric acid,  $\Delta H_1$ , can be determined.

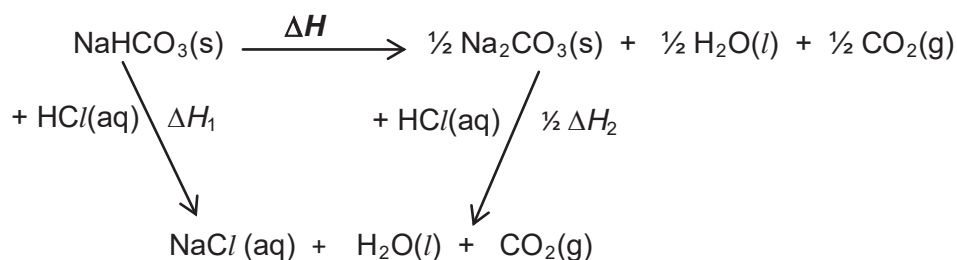
	Expt
Mass of weighing bottle and solid sample / g	a
Mass of weighing bottle and residual solid / g	b
Initial temperature of hydrochloric acid / $^\circ\text{C}$	$T_1$
Final constant temperature of hydrochloric acid / $^\circ\text{C}$	$T_2$ where $T_2 > T_1$

[1]

$$\Delta H_1 = - \frac{50 \times 4.3 \times (T_2 - T_1)}{(a - b) / 106.0} = - 22790 \frac{(T_2 - T_1)}{(a - b)}$$

- (b) Construct a suitable energy cycle and use it to show how  $\Delta H$  can be calculated from  $\Delta H_1$  and  $\Delta H_2$ .

[2]





By Hess' Law,

$$\Delta H = \Delta H_1 - \frac{1}{2} \Delta H_2$$

- (c) *Experiment 2* is carried out to determine  $\Delta H_2$ . The procedure for *Experiment 1* is repeated, using solid sodium hydrogencarbonate in place of solid sodium carbonate.

In a preliminary investigation, the enthalpy change for Reaction 2 is found to be approximately  $+28.5 \text{ kJ mol}^{-1}$ .

Suggest a suitable mass of solid sodium hydrogencarbonate that could be used for *Experiment 2*. Justify your choice with relevant calculations, stating any assumptions made.

You may assume a temperature change of  $5^\circ\text{C}$ .

[2]

No heat gained from surroundings (where heat absorbed by reaction equals heat lost by water) OR no heat lost by polystyrene cup

$$n_{\text{NaHCO}_3} \times 28500 = 50 \times 4.3 \times 5$$

$$n_{\text{NaHCO}_3} = 0.0377 \text{ mol}$$

$$\text{mass of NaHCO}_3 \text{ to be used} = 0.0377 \times 84.0 = \underline{3.17 \text{ g}}$$

- (d) Describe the detailed procedure to find the enthalpy change for Reaction 2. In your plan, you should:

- include appropriate apparatus, masses and volumes of reagents;
- allow for the plotting of a suitable graph to correct for surrounding heat transfer;
- draw table(s) with headings to show the measurements you would make.

[5]

Procedure

- 1 Using a weighing balance, weigh accurately  $4.000 \text{ g}$  of sodium
- 2 hydrogencarbonate in a weighing bottle.
- 3 Using a measuring cylinder, add  $50 \text{ cm}^3$  of hydrochloric acid into a dry polystyrene cup. Support the polystyrene cup on a  $250 \text{ cm}^3$  beaker.
- 4 Stir the solution gently using the thermometer.
- 5 Start the stopwatch.
- 6 Record the temperature of the solution in the polystyrene cup using a thermometer, at  $1 \text{ min}$  interval for  $3 \text{ min}$
- 7 At exactly  $4 \text{ min}$ , tip the solid  $\text{NaHCO}_3$  into the water. Do not measure the temperature at this time.
- 8 Stir the solution gently and record the temperature of the solution at  $4.5 \text{ min}$ . Continue to stir and record the temperature at  $30 \text{ s}$  intervals until solution returns to room temperature.
- 9 Reweigh the weighing bottle and residue after experiment.

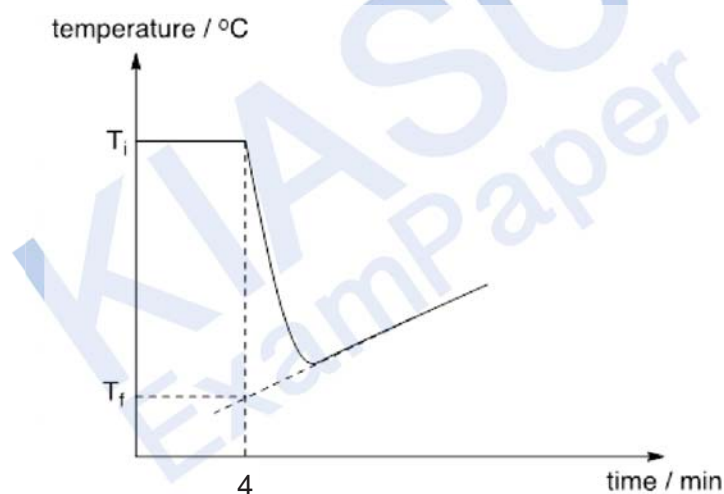
Table

Mass of weighing bottle and solid / g	$m_1$
Mass of weighing bottle and residue after experiment / g	$m_2$
Mass of solid $\text{NaHCO}_3$ used/g	$m_1 - m_2$

Time / min	Temperature of solution / °C
0.0	
0.0	
1.0	
2.0	
3.0	
:	
:	

- (e) Draw a sketch of the graph that you would expect to obtain in the experiment. Indicate clearly on the graph the initial and final temperature that you would read.

[1]



- (f) Suggest and state a reason for a safety precaution for the experiments.

[1]

Wear gloves to avoid direct contact with  $\text{HCl(aq)}$  as it is of high concentration.

- 2 Four samples of known masses of ethanoic acid were placed in separate closed vessels. The temperature in all the vessels was  $120^\circ\text{C}$ . The results were as shown.

Sample	Density / $\text{g m}^{-3}$	Pressure / atm	average $M_r$
1	$1.25 \times 10^4$	6.83	60

2	$9.49 \times 10^4$	31.00	$x$
3	$1.88 \times 10^5$	51.69	119
4	$3.17 \times 10^5$	86.13	120

- (a) (i) Calculate the average relative molecular mass of ethanoic acid,  $x$ , for sample 2.

$$\begin{aligned}
 M_r &= \frac{pRT}{P} \\
 &= \frac{(9.49 \times 10^4) \times 8.31 \times 393}{31.00 \times 1.01 \times 10^5} \\
 &= 99
 \end{aligned}$$

- (ii) Explain the change in average  $M_r$  of ethanoic acid as the pressure is increased gradually.

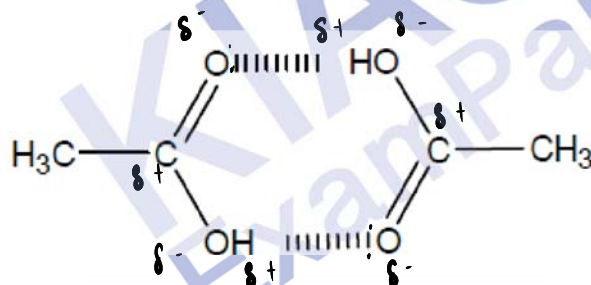
$M_r$  of ethanoic acid increased with increasing pressure.

At low pressure, ethanoic acid exists as monomers, and  $M_r$  (ethanoic acid) =  $M_r(\text{CH}_3\text{COOH})$ ,

At higher pressure, more and more ethanoic acid molecules exist as dimers by forming hydrogen bonds between two acid molecules. This increases the average  $M_r$  as the  $M_r$  of an ethanoic acid dimer =  $2 \times M_r(\text{CH}_3\text{COOH})$

- (iii) Draw the structure of the predominant species of ethanoic acid at high pressures.

[5]



- (b) The label on the bottle of ethanoic acid is misplaced and the acid is mixed up with an unlabelled bottle of dilute hydrochloric acid.

A student proposes to add in  $1 \text{ cm}^3$  of aqueous NaOH to  $5 \text{ cm}^3$  of each acid in two separate boiling tubes. The pH of both resultant solutions is measured before and after two drops of concentrated nitric acid is added to it.

Explain qualitatively if this method works in identifying the two acids.

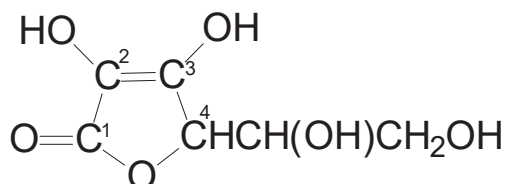
[3]

[Total: 8]

Yes the method may work. Adding of aqueous NaOH to the boiling tube containing ethanoic acid forms a buffer solution which consists of ethanoic acid and sodium ethanoate. The ethanoate ions will react with the conc nitric acid and remove it, hence pH

remains almost unchanged before and after 2 drops of conc. nitric acid is added. However, for the other tube containing aqueous HCl, the pH of the solution will decrease significantly when conc. nitric acid is added since there is an absence of buffer.

- 3 L-ascorbic acid, also known as vitamin C, is an essential nutrient and is required for the synthesis of collagen in humans. The diagram below shows the structure of ascorbic acid:



- (a) State the hybridisation of C-4 and draw the hybrid orbitals, indicating the bond angle. Deduce the molecular shape with respect to C-4. [2]

Hybridisation	Drawing of hybrid orbitals (with the bond angle indicated)	Molecular shape
$sp^3$	109.5°	tetrahedral

- (b) State the total number of isomers of L-ascorbic acid. [1]

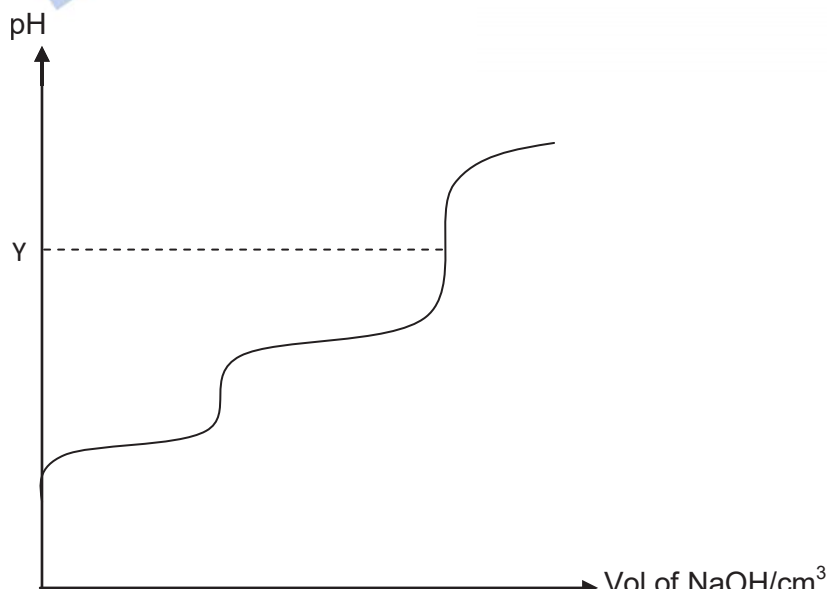
4

- (c) Ascorbic acid is a weak diprotic acid which can be represented as  $H_2A$ . It dissociates in water according to the following equations:



A  $10 \text{ cm}^3$  sample of  $0.100 \text{ mol dm}^{-3}$  of ascorbic acid was titrated with  $0.100 \text{ mol dm}^{-3}$  of sodium hydroxide.

The titration curve for the above titration was given below.



- (i) Explain why the value of  $K_{a1}$  is larger than  $K_{a2}$ .

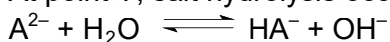
Successive dissociations involve losing of  $H^+$  from an increasingly negatively charged ion, making the loss of  $H^+$  increasingly more difficult.

- (ii) Calculate the initial pH of ascorbic acid.

$$\begin{aligned}[H^+] &= \sqrt{K_{a1} \times c} \\ &= \sqrt{5.6 \times 10^{-2} \times 0.100} \\ &= 0.07483 \text{ mol dm}^{-3} \\ \text{Initial pH of ascorbic acid} &= -\lg(0.07483) = 1.13\end{aligned}$$

- (iii) Explain, with the aid of appropriate equation(s), if the pH at point Y is less than 7, at 7 or more than 7.

At point Y, salt hydrolysis occurs.



Since  $OH^- > [H_3O^+]$  [ $\frac{1}{2}$ ], pH at end-point is basic at  $pH > 7$

- (iv) Calculate the pH of the solution when 45 cm<sup>3</sup> of sodium hydroxide was added to the sample.

$$\begin{aligned}\text{moles of excess } OH^- \text{ added} &= 25/1000 \times 0.1 \\ &= 0.0025 \text{ mol}\end{aligned}$$

$$[\text{excess } OH^-] = \frac{0.0025}{\frac{55}{1000}} = 0.04545 \text{ mol dm}^{-3}$$

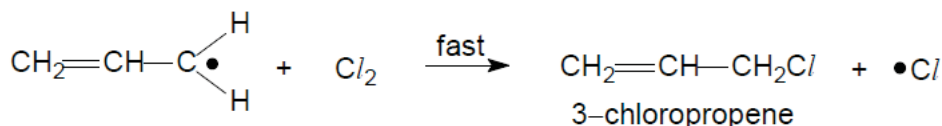
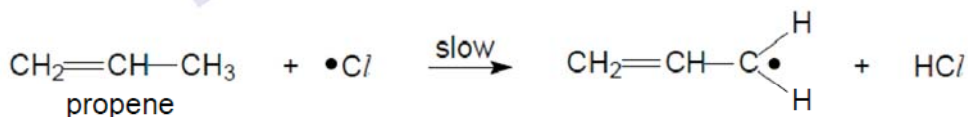
$$pOH = -\lg(0.04545) = 1.342$$

$$pH = 14 - 1.342 = 12.7 \text{ (3 s.f.)}$$

[7]  
[Total: 10]

- 4 The Shell process involves the free radical substitution of gaseous propene to give 3-chloropropene at a high temperature of 400 °C.

- (a) The propagation steps of the free radical substitution are as follows:



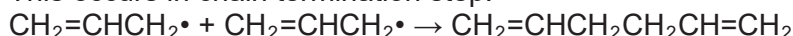
- (i) Identify the catalyst involved in the propagation steps of the Shell process.



- (ii) This process also produces small quantities of  $\text{CH}_2\text{CH}(\text{CH}_2)_2\text{CHCH}_2$ .  
Explain how this might arise.

[2]

This occurs in chain termination step.

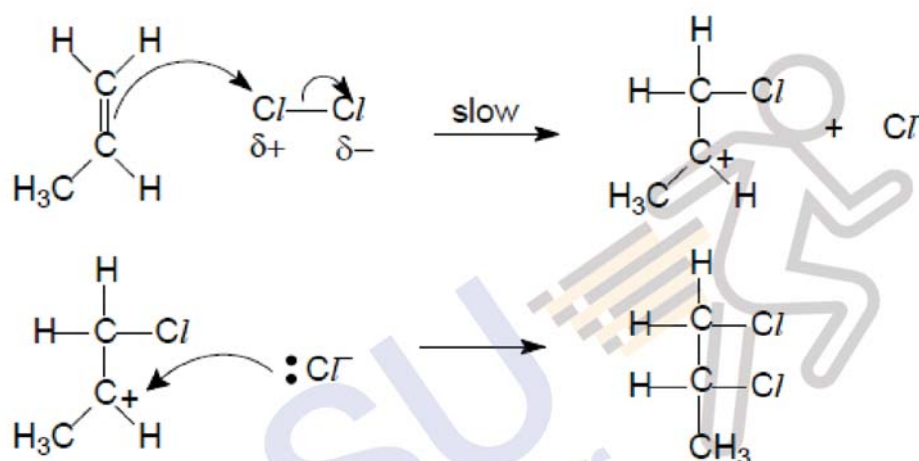


Accept equation or explanation in words.

- (b) At a lower temperature, propene can react with chlorine via a different mechanism to form a product with molecular formula  $\text{C}_3\text{H}_6\text{Cl}_2$ .

Name the type of reaction and describe the mechanism for this reaction, including curly arrows showing the movement of electrons, and all relevant charges.

[3]



Electrophilic addition

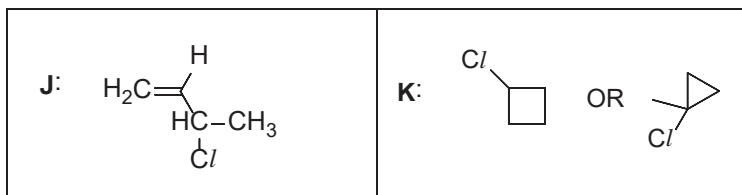
- (c) Two organic compounds, J and K, both with the molecular formula  $\text{C}_4\text{H}_7\text{Cl}$ , are subjected to several chemical tests in order to elucidate their structures.

- (i) The chemical tests and the results are recorded in the table below.  
Fill in the blanks for the type of reaction and the deduction of structure based on observation of each test result.

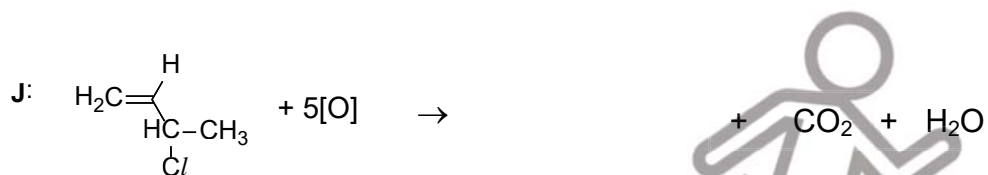
Reagent/ Condition used in chemical test	Type of Reaction	Compound	Observation	Deduction(s)
Cold alkaline potassium manganate(aq)	Mild oxidation	J	Decolourisation of cold dilute $\text{KMnO}_4$ occurred.	Contains $\text{C}=\text{C}$ or alkene
		K	No decolourisation observed.	
Hot acidified potassium manganate(aq).	Strong/ Complete oxidation	J	Effervescence of gas. Decolourisation of hot acidified $\text{KMnO}_4$ occurred.	Contains terminal $\text{C}=\text{C}$ or $\text{H}_2\text{C}=\text{C}$
		K	No decolourisation or gas production observed.	

- (ii) Through analysis with a polarimeter, J was found to rotate plane polarised light at an angle of  $+34^\circ$  while no optical rotation was observed for K.

Deduce and draw the structures for J and K.



- (iii) Write a balanced equation for the reaction between J and hot acidified potassium manganate in the second test, showing the structure of the organic product formed.



[5]  
[Total: 10]

KIASU  
ExamPaper



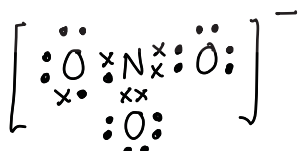
Paper 2 Section B

- 1 Dinitrogen pentoxide,  $\text{N}_2\text{O}_5$ , exists as a colourless crystal that sublimes at  $47^\circ\text{C}$ . In the solid state, each formula unit of  $\text{N}_2\text{O}_5$  consist of two ions. Each ion contains only one nitrogen atom with an oxidation state of +5. In the gaseous state,  $\text{N}_2\text{O}_5$  exists as a molecule.

- (a) (i) State the formulae of the two ions in the solid state and draw the 'dot-and-cross' diagram for the anion.

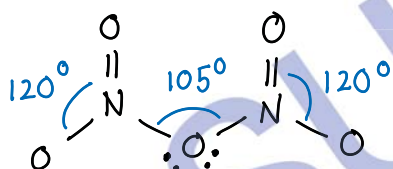
Cation:  $\text{NO}_2^+$

Anion:  $\text{NO}_3^-$

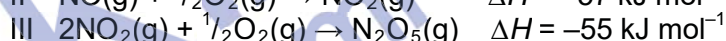


- (ii) Each  $\text{N}_2\text{O}_5$  molecule consists of an N–O–N bond. Draw the Lewis structure for  $\text{N}_2\text{O}_5$  in the gaseous state and suggest the different bond angles in the molecule.

[4]



- (b) Gaseous  $\text{N}_2\text{O}_5$  can be produced by the following reaction sequence in the car engine.



- (i) Suggest why reaction I is endothermic.

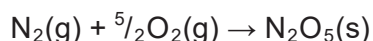
The amount of energy required to break the strong bonds in the reactants (i.e. the  $\text{N}\equiv\text{N}$  and  $\text{O}=\text{O}$ ) is not fully compensated by the amount of energy released from the  $\text{NO}$  bond formation.

- (ii) Nitrogen dioxide is a pollutant that is often produced in car engine. Suggest how the pollutant can be removed in the car engine.

The nitrogen dioxide is converted to nitrogen and oxygen gas in the catalytic converter in the car engine.

- (iii) The standard enthalpy change of formation of  $\text{N}_2\text{O}_5$  is  $-43.1 \text{ kJ mol}^{-1}$ .

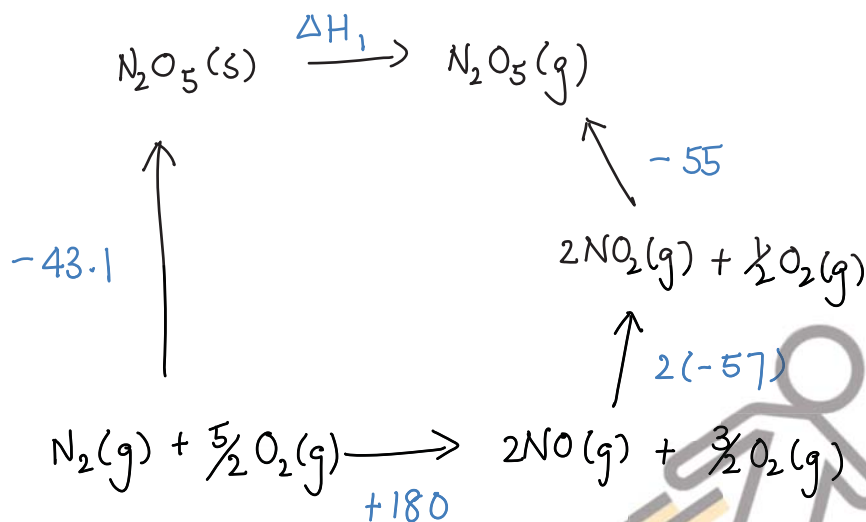
By writing a balanced equation, explain what is meant by the standard enthalpy change of formation of  $\text{N}_2\text{O}_5$ .





- (iv) By drawing a suitable energy cycle and using the data in (b) and (b)(iii), calculate the enthalpy change of sublimation of 1 mole of  $\text{N}_2\text{O}_5$ .

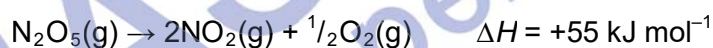
[6]



By Hess' law,

$$\Delta H_1 = -(-43.1) + 180 + 2(-57) - 55 = +54.1 \text{ kJ mol}^{-1}$$

- (c) The gaseous dinitrogen pentoxide produced in step III in (b) can undergo decomposition to give a brown gas and a colourless gas, according to the equation:



The rate of this decomposition can be investigated by monitoring the concentration of nitrogen dioxide produced. The data shown in the table below was obtained during the decomposition of  $2.00 \text{ mol dm}^{-3}$  dinitrogen pentoxide at  $380 \text{ K}$ .

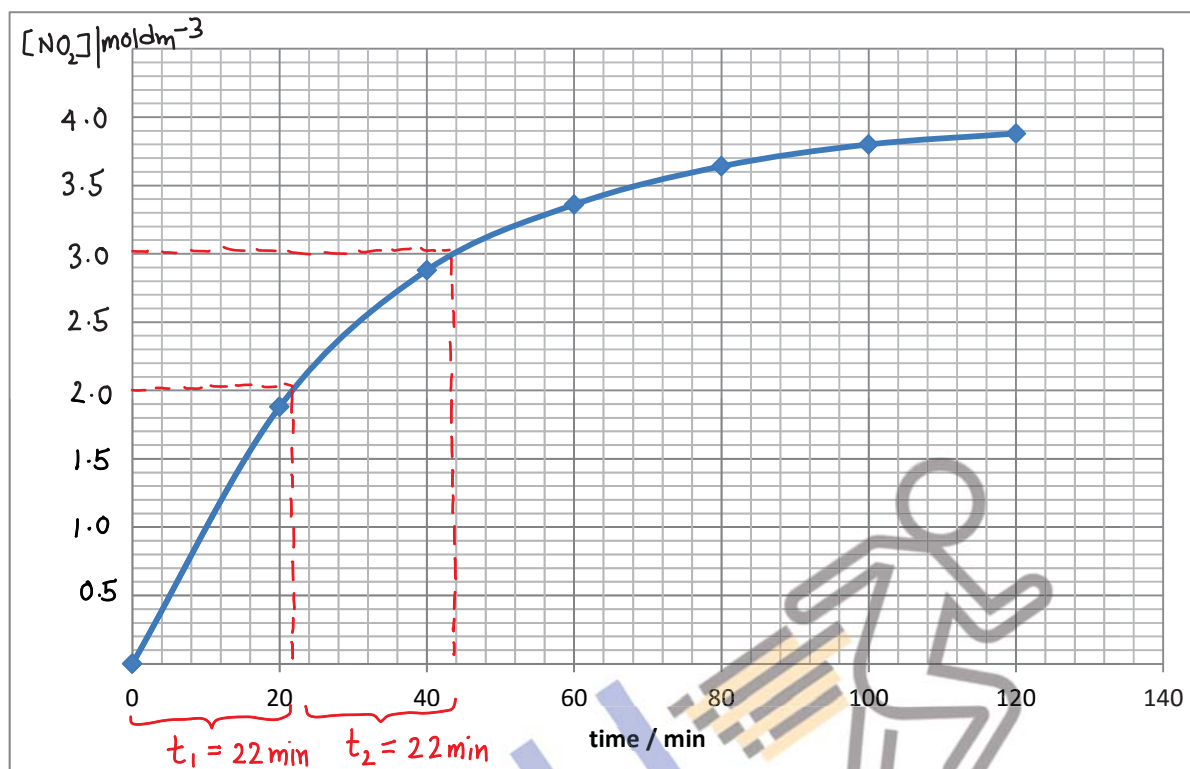
Time / min	$[\text{NO}_2] / \text{mol dm}^{-3}$
0	0
20	1.88
40	2.88
60	3.36
80	3.64
100	3.80
120	3.88

- (i) Briefly describe a method by which the rate of decomposition could be monitored.

The concentration of  $\text{NO}_2$  could be monitored by measuring the colour intensity of the brown  $\text{NO}_2$  using a colorimeter as absorbance (colour intensity) is  $\propto [\text{NO}_2]$ .

Plot the data given in the table on Page 11 on suitable axes. Show all your workings and draw clearly any construction lines on your graph.

(ii) the order of reaction with respect to  $\text{N}_2\text{O}_5$ ;



From the graph, since  $t_1 = t_2 = 22 \text{ min}$ , the half-lives are constant. Hence, the reaction is first order with respect to  $\text{N}_2\text{O}_5$ .

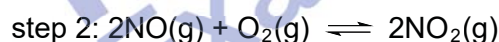
(iii) and calculate a value for the rate constant. Include units in your answer.

[5]

$$k = \ln 2 / 22 = 0.0315 \text{ min}^{-1}$$

(d) A two-step mechanism has been proposed for this decomposition of  $\text{N}_2\text{O}_5$ :

step 1: \_\_\_\_\_



(i) Write a balanced equation for step 1 for the proposed mechanism.



(ii) In step 2, the rate constant for the forward reaction and backward reaction are found to be  $2.6 \times 10^3 \text{ dm}^6 \text{ mol}^{-2} \text{ s}^{-1}$  and  $4.1 \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$  respectively at  $380^\circ\text{C}$ .

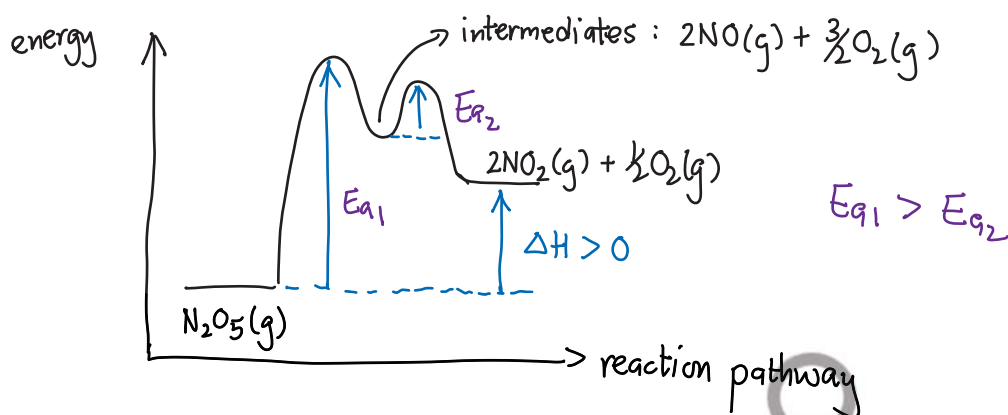
Write the expression for the equilibrium constant,  $K_c$ . Hence, calculate a value for  $K_c$ , stating its units.

$$K_c = [\text{NO}_2]^2 / [\text{NO}]^2[\text{O}_2]$$

$$K_c = 2.6 \times 10^3 / 4.1 = 6.3 \times 10^2 \text{ mol}^{-1} \text{ dm}^3$$

- (iii) Sketch an energy profile diagram for the proposed mechanism represented by step 1 and step 2. Label your diagram clearly with the reactants, products and relevant enthalpy change. Numerical values of the enthalpy changes are not required.

[5]



- 2 The solubility of solid lead iodate(V),  $\text{Pb}(\text{IO}_3)_2$ , in water is low.

The  $K_{\text{sp}}$  of lead iodate(V) could be determined through the following steps, via titrimetric analysis.

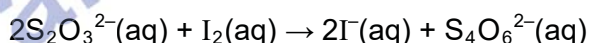
A sample of the salt is mixed with  $1 \text{ dm}^3$  water to form a mixture, where an equilibrium between the solid salt and its aqueous ions is established.



Step 1: The mixture is filtered and the filtrate collected for step 2.

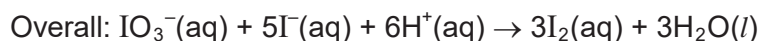
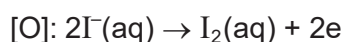
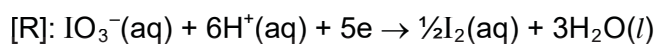
Step 2: When excess solid KI is added to  $500 \text{ cm}^3$  of the acidified filtrate, a comproportionation reaction occurs and iodine is liberated.

Step 3: The liberated iodine in a  $25 \text{ cm}^3$  aliquot of the resultant solution (from step 2) is then titrated with  $12 \text{ cm}^3$  of  $0.001 \text{ mol dm}^{-3}$  sodium thiosulfate.



- (a) Write a balanced reduction half-equation and the overall ionic equation for the comproportionation reaction in step 2.

[2]



- (b) The mixture *must* be filtered in step 1 before KI is added to the filtrate collected.

- (i) Explain why it is necessary to filter the mixture before adding KI.

The salt mixture must be filtered to separate the insoluble  $\text{Pb}(\text{IO}_3)_2$  from the dissolved ions. The presence of the solid will cause the solubility equilibrium to shift toward the ions as dissolved iodate(V) ions are reacted away by KI, according to Le Chatelier's Principle. This renders the determination of the equilibrium concentration

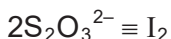
of iodate(V) ions impossible.

- (ii) Describe how the end-point of the iodometric titration could be determined.

[4]

Starch can be used as the indicator to detect the end-point. It is added when the brown iodine solution turns pale yellow. The end-point is then reached when the blue-black iodine starch complex turns colourless.

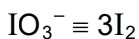
- (c) (i) Calculate the amount of iodine liberated in 500 cm<sup>3</sup> of the acidified filtrate in step 2.



$$n_{\text{iodine}} \text{ in } 25 \text{ cm}^3 \text{ aliquot} = \frac{1}{2} n_{\text{thiosulfate}} = \frac{1}{2} (0.012 \times 0.001) \\ = 6.00 \times 10^{-6} \text{ mol}$$

$$n_{\text{iodine}} \text{ in } 500 \text{ cm}^3 \text{ filtrate} = (6.00 \times 10^{-6} / 25) \times 500 \\ = 1.20 \times 10^{-4} \text{ mol}$$

- (ii) Hence or otherwise, calculate the concentration of iodate(V) ions in the acidified filtrate.



$$n_{\text{iodate(V)}} \text{ in } 500 \text{ cm}^3 \text{ filtrate} = \frac{1}{3} n_{\text{iodine}} \\ = 4.00 \times 10^{-5} \text{ mol}$$

$$[\text{IO}_3^-] \text{ in filtrate} = 4.00 \times 10^{-5} / 0.500 = 8 \times 10^{-5} \text{ mol dm}^{-3}$$

- (iii) Write an expression for the solubility product of lead iodate(V) and determine its value, using your answers in (c)(ii). Include the units for your answer.

[4]

$$K_{\text{sp}} = [\text{Pb}^{2+}][\text{IO}_3^-]^2 \\ = (8 \times 10^{-5} \times \frac{1}{2})(8 \times 10^{-5})^2 \\ = 2.56 \times 10^{-13} \text{ mol}^3 \text{ dm}^{-9}$$

- (d) The tendency for the dissolution of lead iodate(V) to reach the state of equilibrium is driven by the Gibbs free energy,  $\Delta G^\theta$  and this relationship can be defined by the following equation:

$$\Delta G^\theta = -RT \ln K_{\text{sp}}, \quad \text{where } R \text{ is the gas constant}$$

- (i) Using the above equation and your answer in (c)(iii), calculate  $\Delta H^\theta$  for the dissolution of lead iodate(V), given that  $\Delta S^\theta = +200 \text{ J K}^{-1} \text{ mol}^{-1}$ .

$$\Delta G^\theta = -(8.31)(298) \ln(5.54 \times 10^{-11}) \\ = +58.49 \text{ kJ mol}^{-1}$$

$$\Delta G^\theta = \Delta H^\theta - T\Delta S^\theta$$

$$\Delta H^\theta = +58.49 + (298)(0.200) = +118 \text{ kJ mol}^{-1}$$

- (ii) Explain how the positive signs of  $\Delta H^\theta$  and  $\Delta S^\theta$  relate to the changes that occur at the molecular level for the dissolution of the salt.

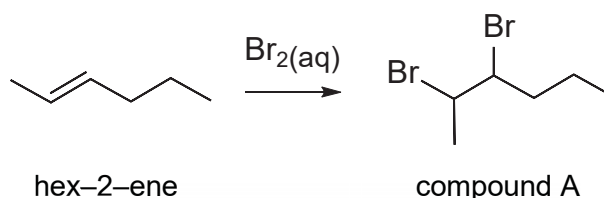
$\Delta H^\theta > 0$  as a large amount of energy is required to overcome the strong ionic bonds between the  $\text{Pb}^{2+}$  and  $\text{IO}_3^-$  ions in the giant ionic structure, thus it is an endothermic reaction.

$\Delta S^\theta > 0$  as system gets more disordered since there is an increase in the number of particles.. In addition, the ions in the ionic solid are organised in a rigid lattice structure whereas the ions in aqueous solution are free to move randomly through

the solvent.

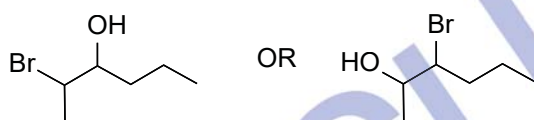
[4]

- (e) A student attempts to synthesise compound A from liquid hex-2-ene. He adds aqueous bromine to hex-2-ene and stirs the mixture for some time, using a magnetic stirrer, in the absence of light.

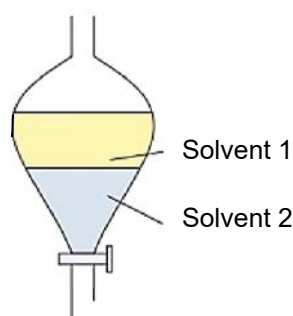


- (i) Explain why compound A will not be the major product formed and give the structure of the major product formed.

When *aqueous* bromine is used, the large amount of  $\text{H}_2\text{O}$  molecules present will act as the nucleophile to attack the carbocation intermediate (bromonium ion), instead of the  $\text{Br}^-$  ions.



- (iii) After the synthesis, the student attempts to extract compound A from the reaction mixture using liquid pentane. He adds liquid pentane into the reaction mixture and two immiscible layers are formed, after shaking the mixture thoroughly. Compound A will preferentially dissolve in one of the layers. Given that the density of pentane is  $0.63 \text{ g cm}^{-3}$ , state and explain which solvent layer will have more of the dissolved compound A



[6]

[Total: 20 marks]

Solvent 1 will have more of dissolved compound A as it is the less dense pentane layer.

Molecules of compound A can form favourable van der Waals' forces of comparable strength, compared to the original interactions, with pentane molecules. The solvation process releases sufficient amount of energy to allow compound A molecules to intermingle with pentane molecules and dissolves.