

Please check the examination details below before entering your candidate information

Candidate surname					Other names				
Centre Number					Candidate Number				
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**Pearson Edexcel International Advanced Level**

**Time** 1 hour 30 minutes **Paper reference** **WCH12/01**

**Chemistry**

**International Advanced Subsidiary/Advanced Level**

**UNIT 2: Energetics, Group Chemistry, Halogenoalkanes and Alcohols**

**You must have:**  
Scientific calculator, Data Booklet, ruler

Total Marks

## Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided  
– *there may be more space than you need.*

## Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets  
– *use this as a guide as to how much time to spend on each question.*
- In the question marked with an **asterisk (\*)**, marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.
- A Periodic Table is printed on the back cover of this paper.

## Advice

- Read each question carefully before you start to answer it.
- Show all your working in calculations and include units where appropriate.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ►

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## SECTION A

Answer ALL the questions in this section.

You should aim to spend no more than 20 minutes on this section.

For each question, select one answer from A to D and put a cross in the box ☐. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☐.

- 1 Which equation represents the standard enthalpy change of formation,  $\Delta_f H^\ominus$ , for aluminium oxide?

- ☐ A  $2\text{Al(s)} + 1\frac{1}{2}\text{O}_2\text{(g)} \rightarrow \text{Al}_2\text{O}_3\text{(s)}$
- ☐ B  $2\text{Al(s)} + 3\text{O(g)} \rightarrow \text{Al}_2\text{O}_3\text{(s)}$
- ☐ C  $4\text{Al(s)} + 3\text{O}_2\text{(g)} \rightarrow 2\text{Al}_2\text{O}_3\text{(s)}$
- ☐ D  $4\text{Al(s)} + 6\text{O(g)} \rightarrow 2\text{Al}_2\text{O}_3\text{(s)}$

(Total for Question 1 = 1 mark)

- 2 How does an oxidising agent change during a redox reaction?

	Electrons	Oxidation number
<input type="checkbox"/> A	gains electrons	decreases
<input type="checkbox"/> B	gains electrons	increases
<input type="checkbox"/> C	loses electrons	decreases
<input type="checkbox"/> D	loses electrons	increases

(Total for Question 2 = 1 mark)

- 3 Which of these compounds would be expected to have the **highest** boiling temperature?

- ☐ A  $(\text{CH}_3)_3\text{COH}$
- ☐ B  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
- ☐ C  $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)_2$
- ☐ D  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$

(Total for Question 3 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.



4 What is the name of the compound with the formula  $\text{KClO}_2$ ?

- ☐ A potassium chlorate(II)  
☐ B potassium chlorate(III)  
☐ C potassium chlorate(IV)  
☐ D potassium chlorate(V)

(Total for Question 4 = 1 mark)

5 A small piece of calcium is added to a beaker of distilled water.

(a) Which is the equation for this reaction?

(1)

- ☐ A  $\text{Ca} + \text{H}_2\text{O} \rightarrow \text{CaO} + \text{H}_2$   
☐ B  $\text{Ca} + 2\text{H}_2\text{O} \rightarrow \text{CaO}_2 + 2\text{H}_2$   
☐ C  $\text{Ca} + \text{H}_2\text{O} \rightarrow \text{CaOH} + \frac{1}{2}\text{H}_2$   
☐ D  $\text{Ca} + 2\text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2 + \text{H}_2$

(b) Which element is oxidised and which is reduced when calcium reacts with water?

(1)

	Element oxidised	Element reduced
<input type="checkbox"/> A	calcium	hydrogen
<input type="checkbox"/> B	calcium	oxygen
<input type="checkbox"/> C	hydrogen	calcium
<input type="checkbox"/> D	hydrogen	oxygen

(Total for Question 5 = 2 marks)

6 Which is the ionic equation for the reaction of solid barium carbonate with dilute hydrochloric acid?

- ☐ A  $\text{BaCO}_3(\text{s}) + 2\text{H}^+(\text{aq}) \rightarrow \text{Ba}^{2+}(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$   
☐ B  $\text{Ba}_2\text{CO}_3(\text{s}) + 2\text{H}^+(\text{aq}) \rightarrow 2\text{Ba}^+(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$   
☐ C  $\text{CO}_3^{2-}(\text{s}) + 2\text{H}^+(\text{aq}) \rightarrow \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$   
☐ D  $\text{CO}_3^{2-}(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow 2\text{Cl}^-(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$

(Total for Question 6 = 1 mark)

- 7 The presence of ammonium ions in a compound can be shown by adding a reagent, warming the mixture and testing the gas evolved.

What is the reagent and the result of the test for the gas evolved?

	Reagent	Result of test for gas
<input type="checkbox"/> A	HCl(aq)	damp blue litmus paper turns red
<input type="checkbox"/> B	HCl(aq)	damp red litmus paper turns blue
<input type="checkbox"/> C	NaOH(aq)	damp blue litmus paper turns red
<input type="checkbox"/> D	NaOH(aq)	damp red litmus paper turns blue

(Total for Question 7 = 1 mark)

- 8 Aqueous chlorine is added to an aqueous solution of potassium iodide. A non-polar organic solvent is then added and the mixture is shaken. The layers are allowed to separate.

What colour is seen in the organic layer?

- ☐ A brown  
☐ B green  
☐ C orange  
☐ D violet

(Total for Question 8 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.



9 A titration is carried out by adding dilute sulfuric acid from a burette to aqueous sodium hydroxide in a conical flask. The indicator is methyl orange.

(a) What is the colour change of the indicator at the end-point of this titration?

(1)

- ☐ **A** red to orange
- ☐ **B** red to yellow
- ☐ **C** yellow to orange
- ☐ **D** yellow to red

(b) A student carried out the first titration and did not notice that there was an air bubble between the tap and the tip of the burette. During the titration, the air bubble filled with acid.

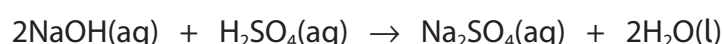
The student then carried out two accurate titrations in which there was no air bubble in the burette. There were no other errors in these titrations.

Which of these could be the three titres for this student?

(1)

	First titre / cm <sup>3</sup>	Second titre / cm <sup>3</sup>	Third titre / cm <sup>3</sup>
<input type="checkbox"/> <b>A</b>	22.65	22.65	22.65
<input type="checkbox"/> <b>B</b>	22.65	22.35	23.25
<input type="checkbox"/> <b>C</b>	22.80	22.35	22.40
<input type="checkbox"/> <b>D</b>	22.80	23.25	23.30

(c) 25.0 cm<sup>3</sup> of 0.100 mol dm<sup>-3</sup> aqueous sodium hydroxide required a mean titre of 18.70 cm<sup>3</sup> of sulfuric acid.



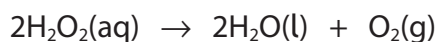
What is the concentration, in mol dm<sup>-3</sup>, of the sulfuric acid?

(1)

- ☐ **A** 0.0374
- ☐ **B** 0.0668
- ☐ **C** 0.134
- ☐ **D** 0.267

(Total for Question 9 = 3 marks)

10 Hydrogen peroxide decomposes as shown.



(a) A catalyst increases the rate of decomposition by

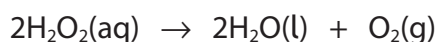
(1)

- ☐ **A** increasing the average kinetic energy of the  $\text{H}_2\text{O}_2$  molecules
- ☐ **B** decreasing the average kinetic energy of the  $\text{H}_2\text{O}_2$  molecules
- ☐ **C** increasing the activation energy of the reaction
- ☐ **D** decreasing the activation energy of the reaction

(b) A bottle of hydrogen peroxide is labelled as '10 volume'.

This means that  $1\text{ cm}^3$  of hydrogen peroxide solution decomposes to produce  $10\text{ cm}^3$  oxygen at room temperature and pressure (r.t.p.).

What is the concentration of 10 volume hydrogen peroxide, in  $\text{mol dm}^{-3}$ ?



[Molar volume of gas at r.t.p. =  $24\,000\text{ cm}^3\text{ mol}^{-1}$ ]

(1)

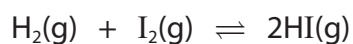
- ☐ **A** 0.100
- ☐ **B** 0.208
- ☐ **C** 0.417
- ☐ **D** 0.833

(Total for Question 10 = 2 marks)

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- 11 A mixture of hydrogen and iodine is left in a sealed container at 300 °C until equilibrium is established.



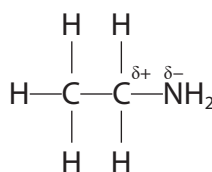
The equilibrium mixture is then cooled and the colour of the mixture darkens.

Which is correct?

	Change in position of equilibrium when the system is cooled	Enthalpy change of forward reaction
<input type="checkbox"/> A	left	endothermic
<input type="checkbox"/> B	left	exothermic
<input type="checkbox"/> C	right	endothermic
<input type="checkbox"/> D	right	exothermic

(Total for Question 11 = 1 mark)

- 12 The structure of ethylamine is shown.



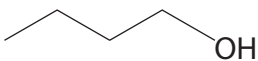
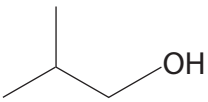
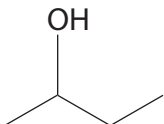
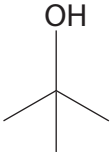
What type of reagent will attack the  $\text{C}^{\delta+}$  atom?

- ☐ A electrophile
- ☐ B free radical
- ☐ C nucleophile
- ☐ D oxidising agent

(Total for Question 12 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

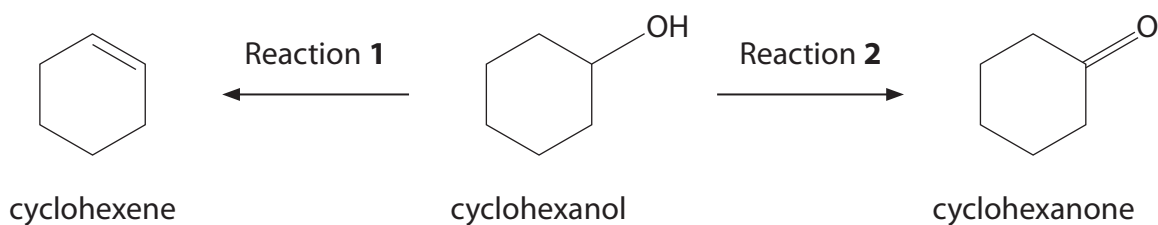
13 Which of these alcohols will produce a carboxylic acid when heated under reflux with acidified potassium dichromate(VI)?

<b>P</b> 	<b>Q</b> 
<b>R</b> 	<b>S</b> 

- ☐ **A** P only  
☐ **B** P and Q only  
☐ **C** P, Q and R only  
☐ **D** P, Q, R and S

(Total for Question 13 = 1 mark)

14 Two reactions of cyclohexanol are shown.



(a) What is the reagent for Reaction 1?

(1)

- ☐ **A** acidified potassium manganate(VII)  
☐ **B** aqueous bromine  
☐ **C** concentrated phosphoric(V) acid  
☐ **D** phosphorus(V) chloride



(b) The reagent for Reaction 2 is acidified potassium dichromate(VI).

Which equation best represents this reaction?

(1)

- ☐ **A**  $\text{C}_6\text{H}_{11}\text{OH} \rightarrow \text{C}_6\text{H}_{10}\text{O} + \text{H}_2$
- ☐ **B**  $\text{C}_6\text{H}_{11}\text{OH} \rightarrow \text{C}_6\text{H}_{10}\text{O} + 2[\text{H}]$
- ☐ **C**  $\text{C}_6\text{H}_{11}\text{OH} + [\text{O}] \rightarrow \text{C}_6\text{H}_{10}\text{O} + \text{H}_2\text{O}$
- ☐ **D**  $\text{C}_6\text{H}_{11}\text{OH} + \frac{1}{2}\text{O}_2 \rightarrow \text{C}_6\text{H}_{10}\text{O} + \text{H}_2\text{O}$

(c) Cyclohexanol and cyclohexene each has a peak in their infrared spectrum which is **not** present for the other compound.

Which are these peaks?

(1)

	Peak only in cyclohexanol / $\text{cm}^{-1}$	Peak only in cyclohexene / $\text{cm}^{-1}$
<input type="checkbox"/> <b>A</b>	2962-2853	1669-1645
<input type="checkbox"/> <b>B</b>	2962-2953	1720-1700
<input type="checkbox"/> <b>C</b>	3750-3200	1669-1645
<input type="checkbox"/> <b>D</b>	3750-3200	1720-1700

(Total for Question 14 = 3 marks)

**TOTAL FOR SECTION A = 20 MARKS**

## SECTION B

**Answer ALL the questions. Write your answers in the spaces provided.**

**15** This question is about calcium carbonate,  $\text{CaCO}_3$ .

(a) Calcium carbonate decomposes on heating.



Explain why calcium carbonate decomposes at a higher temperature than magnesium carbonate, in terms of the charge and size of the cations.

(3)

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(b) Calcium carbonate reacts with dilute hydrochloric acid.



A student determines the initial rate of this reaction by collecting the carbon dioxide in a gas syringe and measuring the volume at regular time intervals.

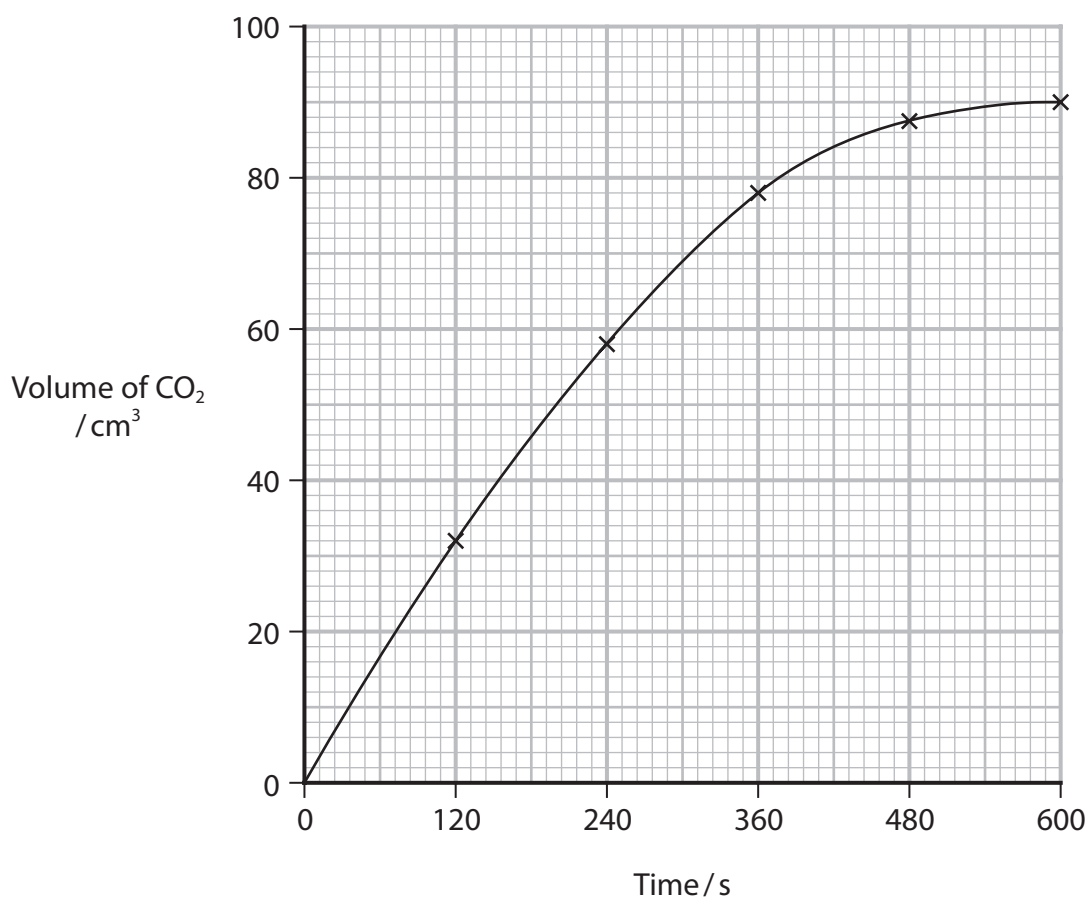
- (i) The gas syringe can measure a maximum of  $100\text{ cm}^3$  of gas.

Calculate the **maximum** volume of  $0.500\text{ mol dm}^{-3}$  hydrochloric acid that can be added to excess calcium carbonate at room temperature and pressure (r.t.p.) without exceeding the measurable volume of the gas syringe.

[Molar volume of gas at r.t.p. =  $24\,000\text{ cm}^3\text{ mol}^{-1}$ ]

(3)

(ii) The results of the student's experiment are shown on the graph.



Calculate the initial rate of this reaction.  
You **must** show your working on the graph.  
Include units in your answer.

(3)

(iii) The student repeats the experiment but uses hydrochloric acid with a concentration of  $0.250 \text{ mol dm}^{-3}$ . All other variables are kept the same.

State what would happen to the initial rate of reaction and the final volume of carbon dioxide collected.

(1)

Initial rate of reaction

Final volume of carbon dioxide collected

(Total for Question 15 = 10 marks)



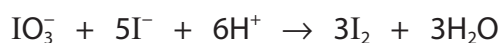
16 This question is about the halogens and some of their compounds.

- (a) Descending the group from fluorine to iodine, the electronegativity of the atoms decreases even though their nuclear charge increases.

Explain the trend in electronegativity.

(2)

- (b) Iodate(V) ions,  $\text{IO}_3^-$ , react with iodide ions in acid solution.



Explain, in terms of the oxidation numbers of iodine in the three species, why this is **not** a disproportionation reaction.

(2)

- (c) Hydrogen bromide and hydrogen iodide reduce sulfuric acid.

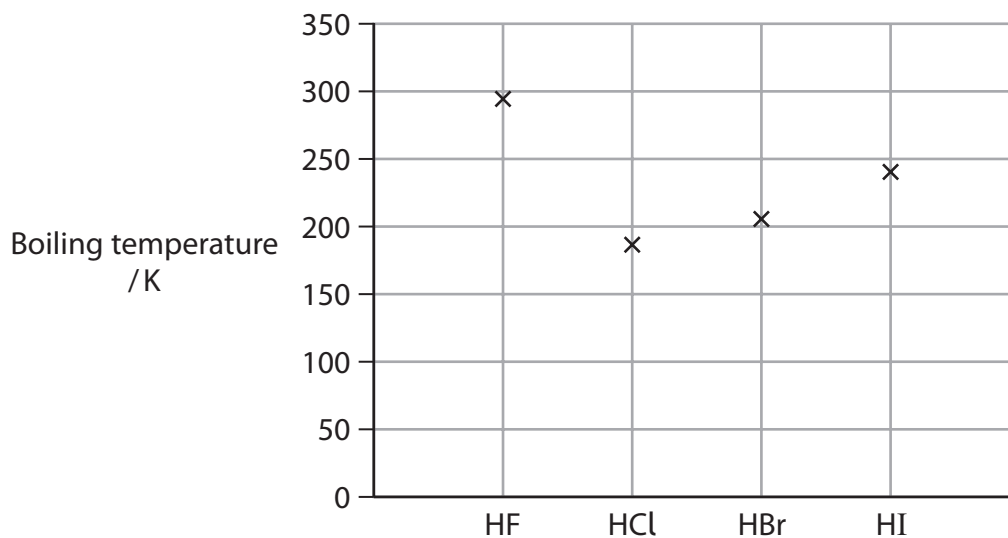
Identify, by name or formula, the **compound** produced containing sulfur with its lowest oxidation number in that reaction.

(1)

Hydrogen halide	Compound produced with the lowest oxidation number of sulfur
HBr	
HI	



(d) The graph shows the boiling temperatures of the hydrogen halides.



Explain the trend in the boiling temperatures of the hydrogen halides.

(4)

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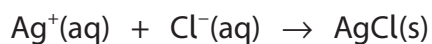
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(e) A sample of seawater was evaporated to dryness.

The solid residue was weighed, then dissolved completely in deionised water.

Excess aqueous silver nitrate was added to the solution.

All the chloride ions in the seawater formed a precipitate of silver chloride.



The precipitate was filtered, washed, dried and weighed.

Results:

Mass of solid residue from seawater = 0.098 g

Mass of silver chloride precipitate = 0.226 g

Calculate the percentage, by mass, of chloride ions in the solid residue.

[Assume silver chloride is the only precipitate.]

(3)

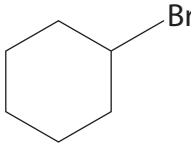
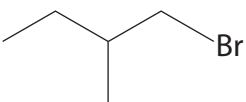
(Total for Question 16 = 12 marks)



**17** This question is about some halogenoalkanes.

- (a) Give the classification of each halogenoalkane shown in the table as primary, secondary or tertiary.

(1)

Halogenoalkane	Classification
	
	

- (b) Samples of 1-iodobutane and 2-chloro-2-methylpropane were hydrolysed using aqueous silver nitrate in ethanol.

Explain whether or not it is possible to predict the relative rate of hydrolysis of these two compounds.

(3)

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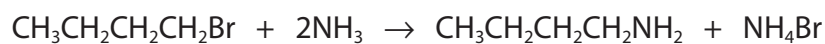
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- (c) Butylamine is formed when 1-bromobutane reacts with excess concentrated alcoholic ammonia.

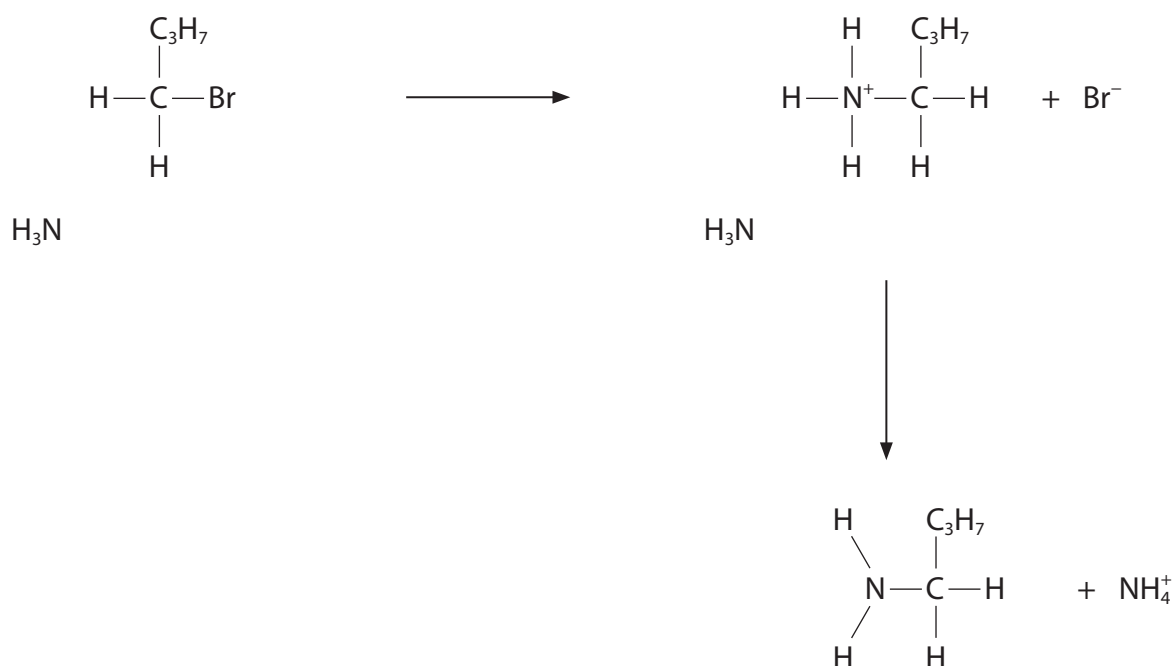


- (i) Give a reason why this reaction should be carried out by heating the reactants in a sealed tube rather than heating under reflux.

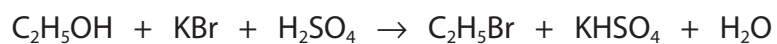
(1)

- (ii) Complete the mechanism for this reaction by adding curly arrows, and any relevant lone pairs and dipoles.

(4)



- (d) Bromoethane is prepared by reacting ethanol with potassium bromide and concentrated sulfuric acid.



Calculate the maximum mass of bromoethane that could be prepared from 4.65 g of ethanol, 14.90 g of potassium bromide and a solution containing 16.35 g of  $\text{H}_2\text{SO}_4$ .

[ $A_r$  values:       $\text{H} = 1.0$     $\text{C} = 12.0$     $\text{O} = 16.0$     $\text{S} = 32.1$     $\text{K} = 39.1$     $\text{Br} = 79.9$ ]

(3)



\*(e) The reaction between 2-bromopropane and potassium hydroxide takes place under two different conditions:

- in aqueous solution
- in ethanolic solution.

Compare and contrast these two reactions.

Include equations for the reactions.

Detailed mechanisms of these reactions are **not** required.

(6)



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(Total for Question 17 = 18 marks)

**TOTAL FOR SECTION B = 40 MARKS**



## SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

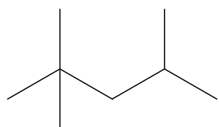
18

### Fuels

Fuels burn in oxygen to release a lot of energy.

Many hydrocarbons and alcohols are used as fuels. During complete combustion, they produce carbon dioxide and water.

Petrol contains 2,2,4-trimethylpentane, an isomer of octane, that promotes smooth combustion.



2,2,4-trimethylpentane

Alcohols, such as methanol and ethanol, can be used as fuels either on their own or as additives in petrol.

- (a) The standard enthalpy change of combustion,  $\Delta_c H^\ominus$ , of 2,2,4-trimethylpentane is  $-5461 \text{ kJ mol}^{-1}$ .

(i) State the two standard conditions for this enthalpy change.

(1)

- (ii) Write the equation for the complete combustion of 2,2,4-trimethylpentane, using **molecular** formulae.

State symbols are not required.

(2)

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(iii) Draw a labelled enthalpy level diagram for the complete combustion of 2,2,4-trimethylpentane.

(2)



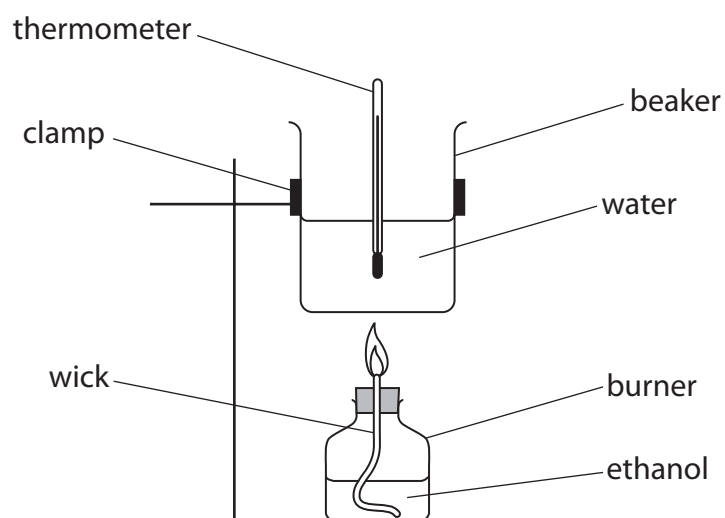
(iv) Calculate the heat energy released during the complete combustion of  $1 \text{ dm}^3$  of 2,2,4-trimethylpentane.

[Density of 2,2,4-trimethylpentane =  $0.692 \text{ g cm}^{-3}$ ]

(3)



- (b) In an experiment to determine the enthalpy change of combustion of ethanol,  $\text{C}_2\text{H}_5\text{OH}$ , a student used the apparatus shown.



Results:

Mass of water = 100.0 g

Mass of ethanol used = 0.305 g

Temperature rise of water = 13.2 °C

- (i) Calculate the enthalpy change of combustion of ethanol.

Give your answer to an appropriate number of significant figures, and include a sign and units.

[Specific heat capacity of water =  $4.18 \text{ J g}^{-1} \text{ °C}^{-1}$ ]

(4)



- (ii) The uncertainty in each thermometer reading is  $\pm 0.05^\circ\text{C}$ .

Calculate the percentage uncertainty in the temperature rise in this experiment.

(1)

- (iii) The student looked in a data book and found the actual value for the standard enthalpy change of combustion of ethanol was more exothermic than the experimental value obtained.

Give **two** reasons for the difference between the data book value and the experimental value, other than referring to standard conditions.

(2)

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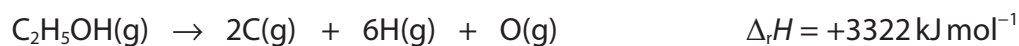
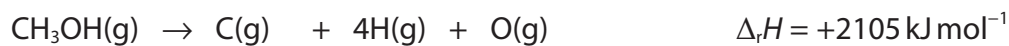
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- (c) The enthalpy changes for the conversion of four compounds in the gas phase into their constituent atoms are shown.



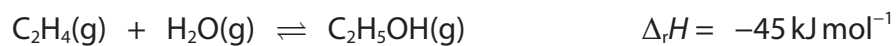
Calculate the bond enthalpy of the C—C bond, in  $\text{kJ mol}^{-1}$ .

You **must** show your working.

(3)



(d) Ethanol can be manufactured by reacting ethene with steam.



This reaction is usually carried out in industry at 300 °C and 70 atm pressure using a catalyst.

Explain the effect on the equilibrium position and the equilibrium yield of ethanol if the reaction is carried out at 300 °C and 200 atm pressure.

(2)

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**(Total for Question 18 = 20 marks)**

**TOTAL FOR SECTION C = 20 MARKS**

**TOTAL FOR PAPER = 80 MARKS**

