Oxford Cambridge and RSA

Tuesday 13 May 2025 – Morning

AS Level Chemistry A

H032/01 Breadth in chemistry

Time allowed: 1 hour 30 minutes

You must have:
- the Data Sheet for Chemistry A

You can use:
- a scientific or graphical calculator
- an HB pencil

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- This document has **24** pages.

ADVICE
- Read each question carefully before you start your answer.

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SECTION A

You should spend a **maximum** of **25 minutes** on this section.

Write your answer to each question in the box provided.

1 The burette readings from a titration are shown below.

Initial reading / cm^3	4.95
Final reading / cm^3	23.10

The burette used has an uncertainty of 0.05 cm^3 for each reading.

What is the percentage uncertainty of the resulting titre?

A 0.22%

B 0.28%

C 0.44%

D 0.55%

Your answer ☐ **[1]**

2 How many p electrons does an atom of chlorine have?

A 5

B 7

C 11

D 17

Your answer ☐ **[1]**

3 What is the number of hydrogen atoms in 6.8 g NH_3?

A 2.408×10^{23}

B 3.612×10^{23}

C 7.224×10^{23}

D 1.806×10^{24}

Your answer ☐ **[1]**

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4 Which reaction to extract iron (Fe) has the highest atom economy?

A $2Al + Fe_2O_3 \rightarrow 2Fe + Al_2O_3$

B $FeO + CO \rightarrow Fe + CO_2$

C $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

D $2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$

Your answer ☐ **[1]**

5 Phosphorus is burnt in oxygen to produce a mixture of oxides.

Which oxide has the closest to 50% by mass of phosphorus?

A PO_2

B P_2O_3

C P_2O_5

D P_4O_9

Your answer ☐ **[1]**

6 What is the oxidation number of S in $Na_2S_2O_3$?

A –4

B –2

C +2

D +4

Your answer ☐ **[1]**

7 Which of the following is **not** a redox reaction?

A $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$

B $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

C $2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$

D $Fe(s) + H_2SO_4(aq) \rightarrow FeSO_4(aq) + H_2(g)$

Your answer ☐ **[1]**

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8 Which compound has molecules with a trigonal planar shape?

A $BeCl_2$

B BCl_3

C NCl_3

D PCl_3

Your answer ☐ **[1]**

9 Which equation describes the second ionisation energy of magnesium?

A $Mg(g) \rightarrow Mg^{2+}(g) + 2e^-$

B $Mg(s) \rightarrow Mg^{2+}(g) + 2e^-$

C $Mg^+(g) \rightarrow Mg^{2+}(g) + e^-$

D $Mg^{2+}(g) + e^- \rightarrow Mg^+(g)$

Your answer ☐ **[1]**

10 Which molecule is polar?

A H_2S

B CO_2

C CCl_4

D C_2F_4

Your answer ☐ **[1]**

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11 The equation for the complete combustion of methanol, CH_3OH, is shown below.

$$CH_3OH(l) + 1\frac{1}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$$

The table shows standard enthalpy changes of formation, $\Delta_f H^{\ominus}$, in kJ mol^{-1}.

Substance	$CH_3OH(l)$	$O_2(g)$	$CO_2(g)$	$H_2O(l)$
$\Delta_f H^{\ominus}$ / kJ mol^{-1}	–239	0	–393	–286

What is the enthalpy change of combustion of $CH_3OH(l)$, in kJ mol^{-1}?

A +726

B +440

C –440

D –726

Your answer ☐ **[1]**

12 Hydrogen and iodine react in the reaction below.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

Which row is correct when pressure is **increased**?

	Rate of reaction	**Equilibrium yield of HI**
A	Increases	Increases
B	Increases	No effect
C	Increases	Decreases
D	Decreases	No effect

Your answer ☐ **[1]**

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13 Which statement is **not** a sustainability benefit of an industrial process using a catalyst?

A Lower temperatures can be used.

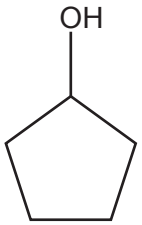
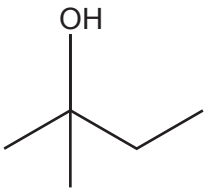
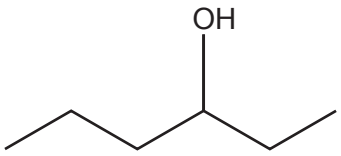
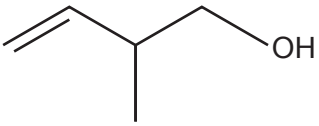
B The position of equilibrium moves towards the products.

C The reaction takes place in less time.

D There is reduced energy demand.

Your answer ☐ **[1]**

14 The skeletal formulae of four alcohols, **W**, **X**, **Y**, **Z**, are shown below.

W	
X	
Y	
Z	

Which pair of alcohols are structural isomers of each other?

A **W** and **X**

B **W** and **Y**

C **W** and **Z**

D **X** and **Y**

Your answer ☐ **[1]**

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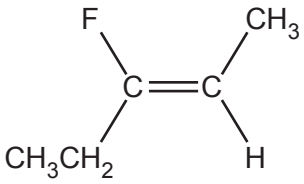
15 A compound is shown below.

What is the systematic name of this compound?



A *E*-3-fluoropent-2-ene

B *E*-3-fluoropent-3-ene

C *Z*-3-fluoropent-2-ene

D *Z*-2-fluoropent-3-ene

Your answer ☐ **[1]**

16 Which equation is a **propagation** step in the catalytic breakdown of ozone?

A $C_2F_2Cl_2 \rightarrow C_2F_2Cl\bullet + Cl\bullet$

B $O_3 + O \rightarrow 2O_2$

C $Cl\bullet + Cl\bullet \rightarrow Cl_2$

D $ClO\bullet + O \rightarrow Cl\bullet + O_2$

Your answer ☐ **[1]**

17 How many structural isomers of $C_5H_{12}O$ are secondary alcohols?

A 1

B 2

C 3

D 4

Your answer ☐ **[1]**

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18 The hydrolysis of 1-iodopropane by aqueous potassium hydroxide takes place at a faster rate than 1-bromopropane.

Which statement explains the different rates of reaction?

A Iodine is less reactive than bromine.

B The C–I bond enthalpy is less than the C–Br bond enthalpy.

C The C–I bond is less polar than a C–Br bond.

D The C–I bond length is shorter than the C–Br bond length.

Your answer ☐ **[1]**

19 In a mass spectrum, which alkene is likely to have a fragment ion at $m/z = 29$?

A $H_2C{=}CHCH{=}CH_2$

B $H_2C{=}C(CH_3)_2$

C $H_3CCH{=}CHCH_3$

D $H_3CCH{=}CHCH_2CH_3$

Your answer ☐ **[1]**

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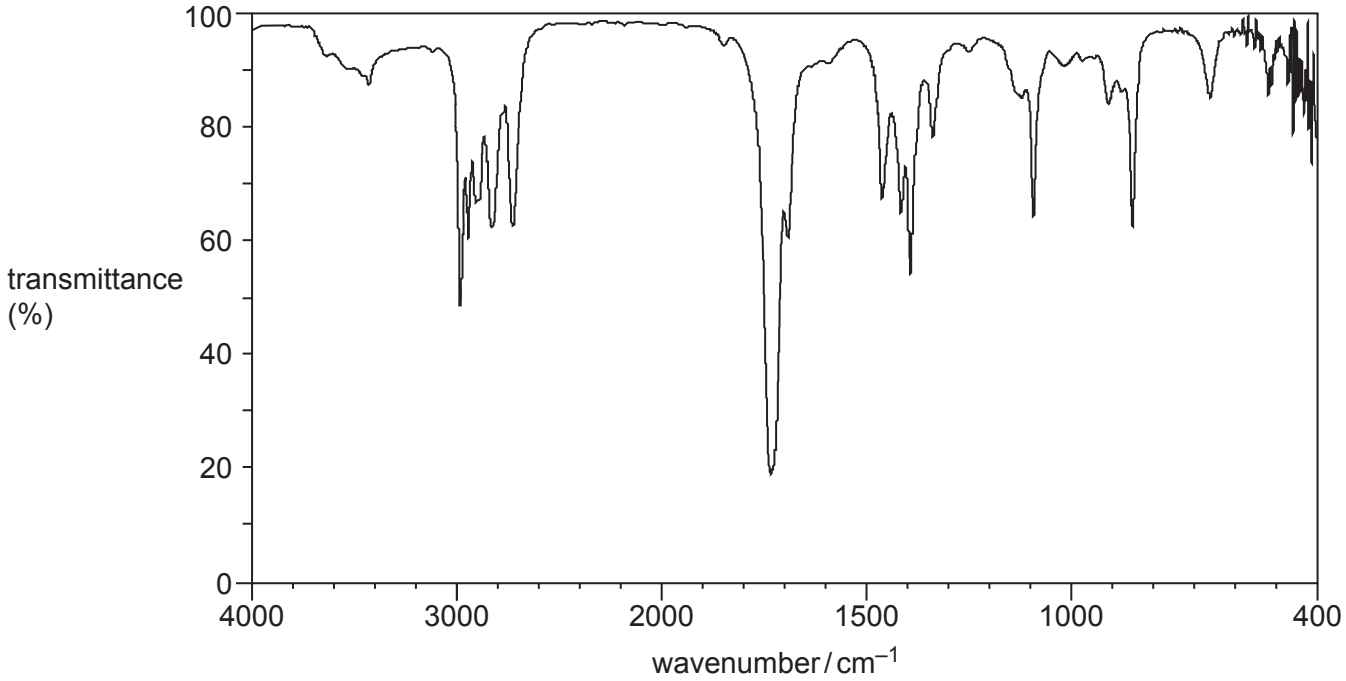
20 The IR spectrum of a compound is shown below.



Which compound could have produced the IR spectrum?

A $CH_3CH{=}CH_2$

B CH_3CH_2CHO

C $CH_3CH_2CH_2OH$

D CH_3CH_2COOH

Your answer ☐ **[1]**

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SECTION B

21 This question is about atomic structure and isotopes of two elements in Period 3.

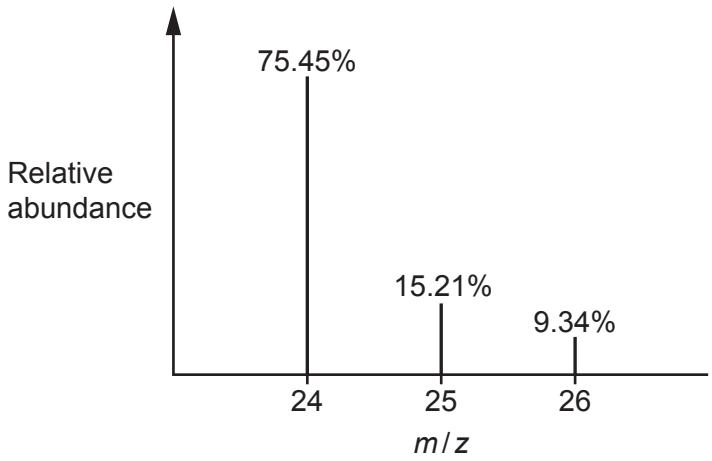
(a) This part of the question is about sulfur.

Complete the table below.

Species	Protons	Neutrons	Electrons
^{34}S			16
		16	18

[2]

(b) The mass spectrum of a sample of magnesium is shown below.



Calculate the relative atomic mass of magnesium in the sample.

Give your answer to **2** decimal places.

Relative atomic mass = ... **[2]**

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(c) Magnesium has a giant metallic structure.

- Draw a labelled diagram to show the bonding and structure in magnesium. Include the correct charges on the metal particles in your diagram.
- Explain how the structure of magnesium allows it to conduct electricity.

Diagram

Explanation .....

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[3]

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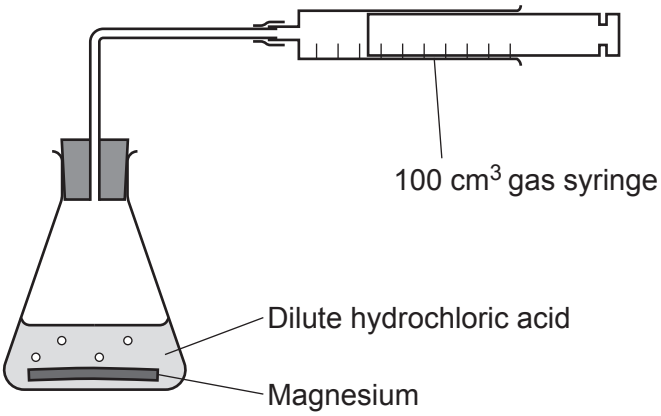
(d) Magnesium reacts with dilute hydrochloric acid, as shown in the equation.

$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

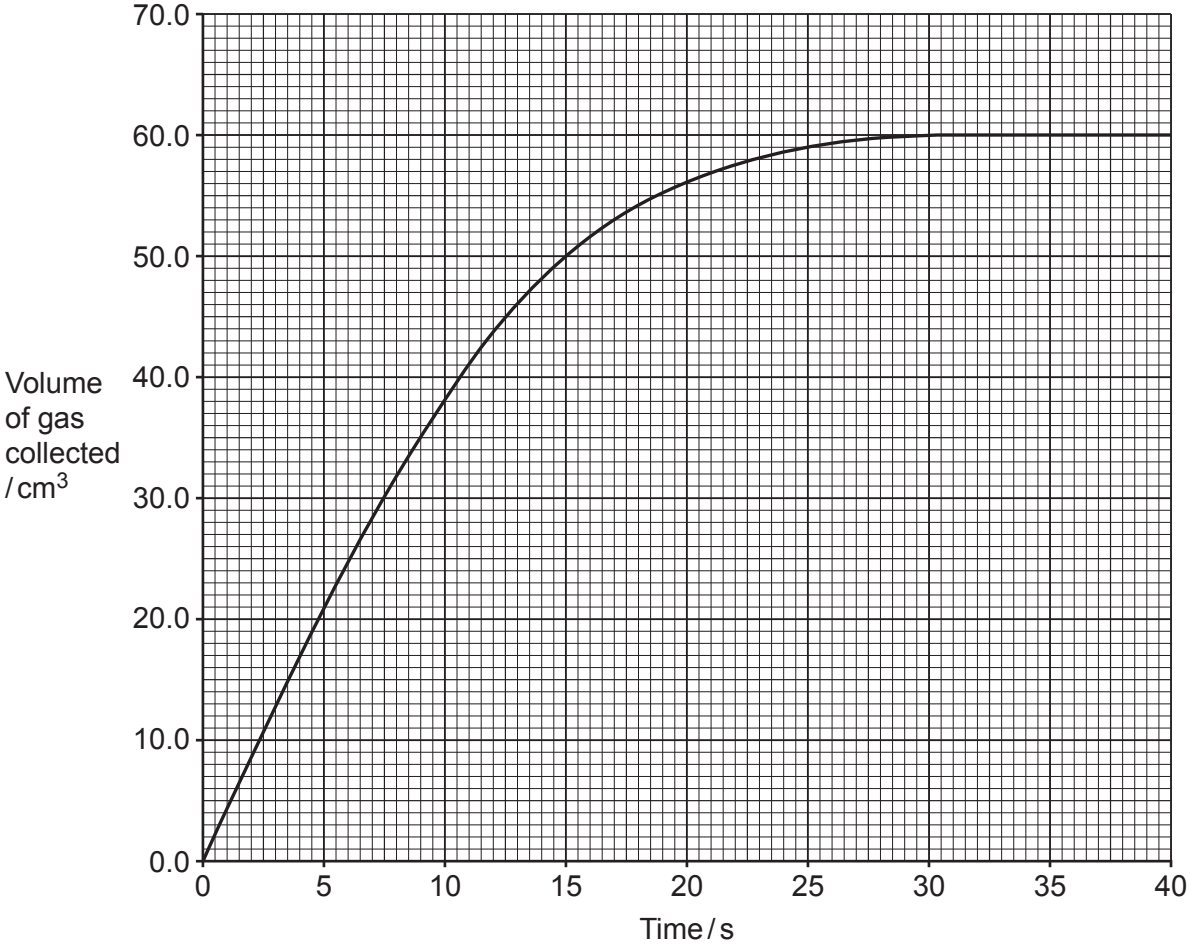
A student reacts an excess of Mg with 24.5 cm^3 $HCl(aq)$ using the apparatus below.



The student measures the volume of gas collected over time. All gas volumes are measured at RTP.

A graph of the student's results is shown in **Fig. 21.1** below.

Fig. 21.1



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(i) Calculate the concentration of HC*l* that the student used.

Give your answer to **2** significant figures and in standard form.

Concentration of HC*l* = ... mol dm^{-3} **[3]**

(ii) Explain the shape of the graph in **Fig. 21.1**, in terms of concentration, collisions and time.

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..... **[3]**

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22 This question is about halogens and their compounds.

(a) An aqueous solution of bromine reacts with cold aqueous sodium hydroxide in a disproportionation reaction.

The equation is shown below.

$Br_2(aq) + 2NaOH(aq) \rightarrow NaBr(aq) + NaBrO(aq) + H_2O(l)$

Explain what is meant by the term **disproportionation**.

Use the equation above and oxidation numbers.

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..... **[3]**

(b) An aqueous solution of chlorine also reacts with cold, aqueous sodium hydroxide. The reaction is more vigorous than the reaction of $Br_2(aq)$ with NaOH(aq) in **(a)**.

(i) Explain why chlorine reacts more vigorously than bromine.

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..... **[3]**

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(ii) Chlorine is used in water treatment.

State **one** disadvantage of treating water with chlorine.

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..... **[1]**

(c) A group of students is provided with aqueous solutions of sodium chloride, sodium bromide and sodium iodide in three unlabelled bottles.

Explain how the students can identify which bottle contains each aqueous solution using precipitation reactions and the solubility of any precipitate formed.

Include an **ionic** equation in your answer.

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..... **[4]**

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23 This question is about equilibrium and bond enthalpies.

The chemical industry manufactures sulfur trioxide, SO_3, by reacting sulfur dioxide, SO_2, and oxygen. This is a reversible reaction which can reach dynamic equilibrium.

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \quad \Delta H = -196\ kJ\ mol^{-1}$ **Equilibrium 23.1**

(a) State **two** features of a **dynamic equilibrium**.

1 .....

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2 .....

.....

[2]

(b) The displayed formulae of SO_2 and SO_3 are shown below.

The bond enthalpies for the S=O bond in SO_2 and SO_3 are **not** the same.

The table shows bond enthalpies.

Bond	**Bond enthalpy / kJ mol^{-1}**
O=O	+494
S=O in SO_2	+522

Calculate the S=O bond enthalpy in **SO_3**.

Use the information in the table and **Equilibrium 23.1**.

Bond enthalpy of S=O in SO_3 = ... kJ mol^{-1} **[3]**

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(c) The table shows equilibrium concentrations for **Equilibrium 23.1**.

$[SO_2(g)]$ / mol dm^{-3}	$[O_2(g)]$ / mol dm^{-3}	$[SO_3(g)]$ / mol dm^{-3}
25.0	108	42.0

For **Equilibrium 23.1**

- write the expression for the equilibrium constant, K_c
- calculate K_c to **3** significant figures and in standard form.

K_c = ... dm^3 mol^{-1}

[3]

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24 This question is about alkenes.

(a) 2-Chloropropene can form an addition polymer.

(i) Draw **two** repeat units of the polymer formed by 2-chloropropene.

[1]

(ii) 2-Chloropropene can be disposed of by combustion. This process releases the greenhouse gas carbon dioxide.

State **one** other problem with this method of disposal.

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..... **[1]**

(b) Pentene, C_5H_{10}, can undergo complete combustion to produce the same products as the combustion of an alkane.

Write the equation for the complete combustion of C_5H_{10}.

..... **[1]**

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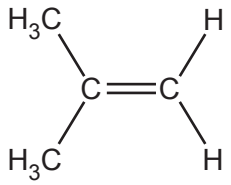
(c) Methylpropene, $(CH_3)_2C{=}CH_2$, reacts with HCl to form a mixture of two products. Compound **A** is the major product.

(i) Outline the mechanism for the formation of the major product, compound **A**.

The structure of $(CH_3)_2C{=}CH_2$ has been provided.

Include curly arrows and relevant dipoles, the structure of compound **A** and the name of the mechanism.



Compound A

Name of mechanism .....

[5]

(ii) Explain why compound **A** is the major product.

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..... **[1]**

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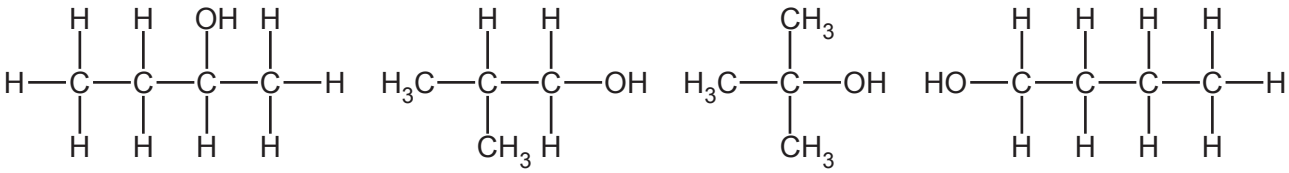
25 This question is about alcohols.

Alcohols **D**, **E**, **F** and **G**, shown below, are structural isomers of $C_4H_{10}O$.



Alcohol **D** Alcohol **E** Alcohol **F** Alcohol **G**

(a) Alcohols **D**, **E**, **F** and **G** are each heated under reflux with $H^+/Cr_2O_7^{2-}$.

Draw the structure of the organic product that is formed from each alcohol.

If there is no reaction, state 'No reaction'.

Alcohol	Organic product
D	
E	
F	
G	

[3]

(b) Alcohols **D**, **E**, **F** and **G** are each heated with concentrated H_2SO_4, which acts as an acid catalyst.

Which alcohol forms a mixture of two alkenes that are structural isomers of one another?

Alcohol ..... **[1]**

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(c) 25.9 g of alcohol **F** is completely combusted in oxygen at a temperature of 100 °C and 1.50×10^5 Pa pressure.

The equation for this reaction is:

$C_4H_{10}O + 6O_2 \rightarrow 4CO_2 + 5H_2O$

Calculate the volume of $CO_2(g)$ produced, in cm^3.

Give your answer to an **appropriate** number of significant figures.

Volume of $CO_2(g)$ = ... cm^3 **[5]**

END OF QUESTION PAPER

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EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.

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