Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Thursday 15 January 2026

Afternoon (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.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **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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P 7 9 0 5 1 A 0 1 2 8

Pearson

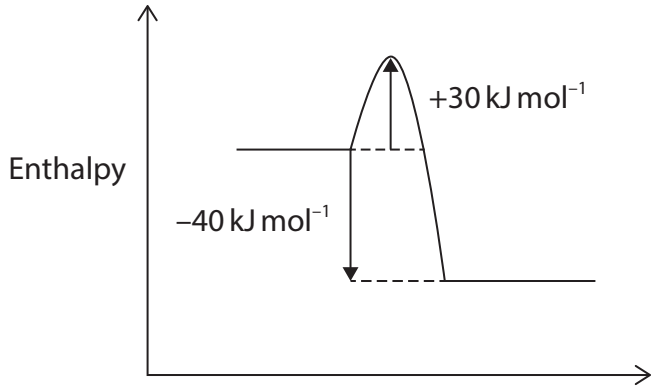
SECTION A

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 The reaction profile for a reversible reaction is shown.



Which statement is correct?

☒ **A** the activation energy for the backward reaction is +70 kJ mol^{-1}

☒ **B** the enthalpy change for the backward reaction is –30 kJ mol^{-1}

☒ **C** the enthalpy change for the forward reaction is –70 kJ mol^{-1}

☒ **D** the enthalpy change for the forward reaction is +40 kJ mol^{-1}

(Total for Question 1 = 1 mark)

2 Which row is correct for the values of the enthalpy changes shown?

	$\Delta_{at}H$	Δ_cH	Δ_fH
☒ **A**	positive or negative	always negative	positive or negative
☒ **B**	always positive	always positive	always negative
☒ **C**	always positive	always negative	positive or negative
☒ **D**	always negative	always negative	always negative

(Total for Question 2 = 1 mark)

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3 In an experiment, 0.25 g of magnesium ribbon was added to 50 cm^3 of copper(II) sulfate solution.
The temperature of the solution increased from 21.0 °C to 34.5 °C.

What is the energy absorbed by the solution, in joules?

- ☒ **A** $50 \times 4.18 \times 13.5$
- ☒ **B** $50 \times 4.18 \div 13.5$
- ☒ **C** $50 \times 4.18 \times 34.5$
- ☒ **D** $50 \times 4.18 \div 34.5$

(Total for Question 3 = 1 mark)

4 What is the enthalpy change for the reaction shown?

$$H_2(g) + CO_2(g) \rightarrow HCOOH(l)$$

[Data: Enthalpy change of formation of methanoic acid = –425 kJ mol^{-1}
Enthalpy change of formation of carbon dioxide = –394 kJ mol^{-1}]

- ☒ **A** –819 kJ mol^{-1}
- ☒ **B** –31 kJ mol^{-1}
- ☒ **C** +31 kJ mol^{-1}
- ☒ **D** +819 kJ mol^{-1}

(Total for Question 4 = 1 mark)

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

5 This question is about the intermolecular forces in four compounds in the liquid state.

(a) Which liquid includes hydrogen bonding as one of its intermolecular forces?

(1)

- ☒ **A** ammonia, NH_3
- ☒ **B** hydrogen bromide, HBr
- ☒ **C** hydrogen sulfide, H_2S
- ☒ **D** silane, SiH_4

(b) Which liquid would be expected to have the strongest London forces between its molecules?

(1)

- ☒ **A** ammonia, NH_3
- ☒ **B** hydrogen bromide, HBr
- ☒ **C** hydrogen sulfide, H_2S
- ☒ **D** silane, SiH_4

(c) Which liquid does **not** contain molecules with a permanent dipole?

(1)

- ☒ **A** ammonia, NH_3
- ☒ **B** hydrogen bromide, HBr
- ☒ **C** hydrogen sulfide, H_2S
- ☒ **D** silane, SiH_4

(Total for Question 5 = 3 marks)

6 Which compound contains sulfur with the highest average oxidation state?

- ☒ **A** Na_2SO_3
- ☒ **B** $Na_2S_2O_4$
- ☒ **C** $Na_2S_3O_6$
- ☒ **D** $Na_2S_4O_6$

(Total for Question 6 = 1 mark)

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7 During a redox reaction, an oxidising agent

- ☒ **A** gains electrons and is oxidised
- ☒ **B** gains electrons and is reduced
- ☒ **C** loses electrons and is oxidised
- ☒ **D** loses electrons and is reduced

(Total for Question 7 = 1 mark)

8 Which equation does **not** represent a disproportionation reaction?

- ☒ **A** $3MnO_4^{2-} + 4H^+ \rightarrow 2MnO_4^- + MnO_2 + 2H_2O$
- ☒ **B** $Cu_2O + H_2SO_4 \rightarrow CuSO_4 + Cu + H_2O$
- ☒ **C** $3IO^- \rightarrow 2I^- + IO_3^-$
- ☒ **D** $MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$

(Total for Question 8 = 1 mark)

9 What is the value of *n* needed to balance the equation shown?

$$ClO_3^- + 6H^+ + ne^- \rightarrow Cl^- + 3H_2O$$

- ☒ **A** 4
- ☒ **B** 5
- ☒ **C** 6
- ☒ **D** 7

(Total for Question 9 = 1 mark)

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

10 This question is about industrial chemistry.

(a) The Haber process for the manufacture of ammonia uses the reaction shown.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3 \quad \Delta H \text{ is negative}$$

Which change will **not** increase the rate of the forward reaction?

(1)

- ☒ **A** decreasing the size of the catalyst pieces
- ☒ **B** increasing the pressure
- ☒ **C** increasing the temperature
- ☒ **D** removing the ammonia as it is formed

(b) During the Ostwald process, when ammonia is converted into nitric acid, several reactions occur.

Which of the reactions has the greatest change in the oxidation number of a nitrogen atom?

(1)

- ☒ **A** $2NO + O_2 \rightarrow 2NO_2$
- ☒ **B** $3NO_2 + H_2O \rightarrow 2HNO_3 + NO$
- ☒ **C** $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$
- ☒ **D** $4NH_3 + 6NO \rightarrow 5N_2 + 6H_2O$

(c) One step in the Contact process to produce sulfuric acid uses the reaction shown.

$$2SO_2 + O_2 \rightleftharpoons 2SO_3 \quad \Delta H \text{ is negative}$$

The reaction is carried out at 450 °C and at a pressure of about 2 atm with a vanadium(V) oxide catalyst.

Which statement is correct for this step?

(1)

- ☒ **A** at a lower temperature the yield of SO_3 decreases
- ☒ **B** at a lower temperature the catalyst does not work efficiently
- ☒ **C** at a higher pressure the yield of SO_3 decreases
- ☒ **D** at a lower pressure the cost of reaction vessels increases

(Total for Question 10 = 3 marks)

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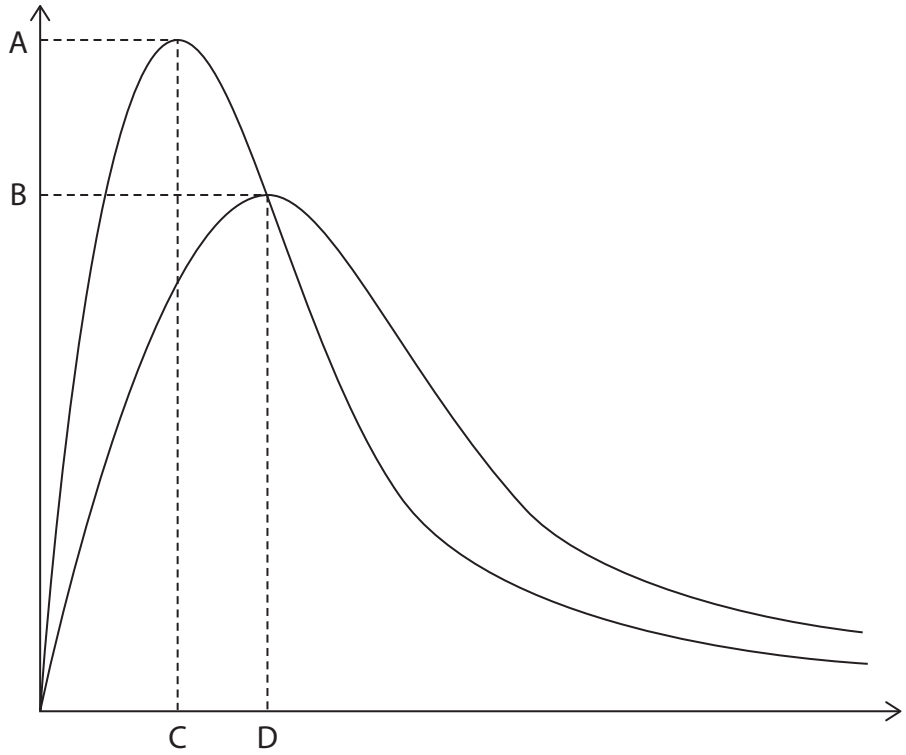
11 The diagram shows Maxwell-Boltzmann distribution curves for a gas at two different temperatures.



Which represents the most probable energy of molecules at the lower temperature?

- ☒ **A** value A
- ☒ **B** value B
- ☒ **C** value C
- ☒ **D** value D

(Total for Question 11 = 1 mark)

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12 When dissolved in water, compounds of vanadium(II) form a solution that is purple in colour. In a sealed system, the solution formed becomes greener as an equilibrium is established with vanadium(III) ions, which are green.

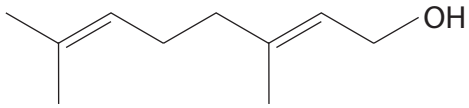
$$V^{2+} + H_2O \rightleftharpoons V^{3+} + \tfrac{1}{2}H_2 + OH^-$$

Which change would make the solution more purple after equilibrium has been re-established?

- ☒ **A** addition of a reagent that removes V^{3+} by precipitation
- ☒ **B** addition of an acid
- ☒ **C** allowing hydrogen to escape as it forms
- ☒ **D** increasing the pH of the solution

(Total for Question 12 = 1 mark)

13 Geraniol is produced by the sweat glands of honeybees and is used to mark the entrance to their hives. The structure of geraniol is shown.



Which statement about geraniol is **not** correct?

- ☒ **A** it changes hot acidified potassium dichromate(VI) from orange to green
- ☒ **B** it contains three CH_3 groups and three CH_2 groups
- ☒ **C** it decolourises a small volume of bromine
- ☒ **D** it exists as two pairs of *cis-trans* isomers

(Total for Question 13 = 1 mark)

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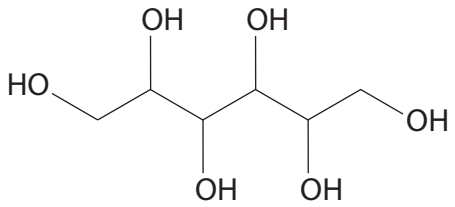
14 The compound shown is used as both an artificial sweetener and as a laxative.



Which functional groups may be produced by oxidation of this compound?

- ☒ **A** aldehydes and carboxylic acids only
- ☒ **B** aldehydes, carboxylic acids and ketones only
- ☒ **C** ketones only
- ☒ **D** none, because the compound does not oxidise

(Total for Question 14 = 1 mark)

15 Cyclohexane is both immiscible with water and less dense than water.
It can be used to extract iodine from an aqueous solution.
Cyclohexane is added to a separating funnel containing an aqueous solution of iodine. The funnel is shaken and the liquids are allowed to separate.

What is the best description of the colour of the two layers?

		lower layer	upper layer
☒	**A**	brown	yellow
☒	**B**	purple	yellow
☒	**C**	yellow	brown
☒	**D**	yellow	purple

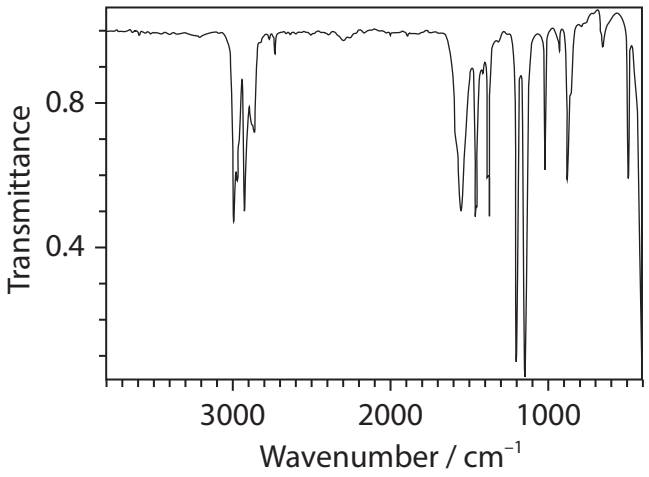
(Total for Question 15 = 1 mark)

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

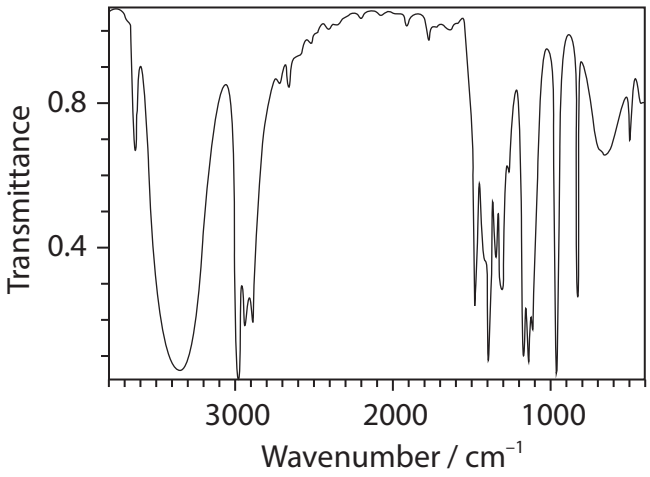
16 2-Iodopropane can be converted via propan-2-ol into propanone.

2-iodopropane → propan-2-ol → propanone

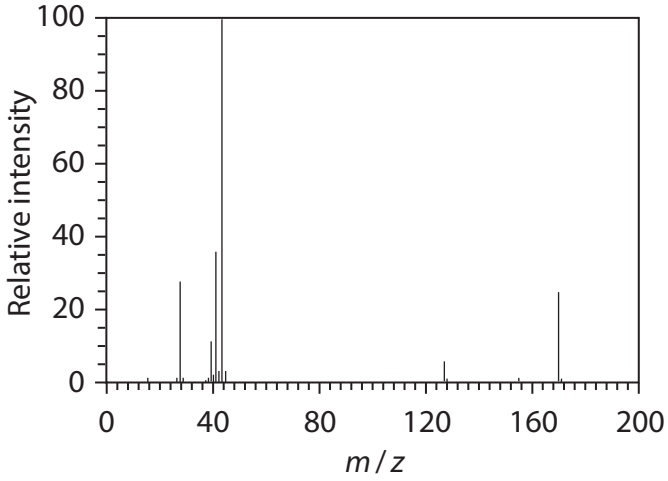
Infrared spectra (ir) and mass spectra (ms) were recorded for each compound.
Four of the six spectra are shown.



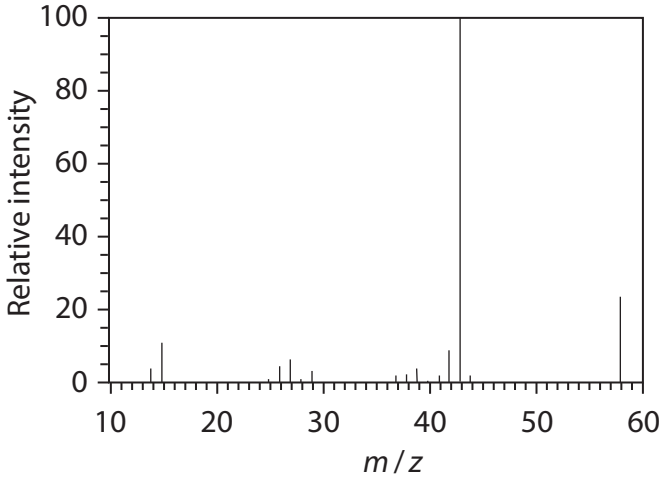
ir 1



ir 2



ms 1



ms 2

Which two spectra are of the same compound?
Use your Data Booklet in making your choice.

☒ **A** ir 1 and ms 1

☒ **B** ir 1 and ms 2

☒ **C** ir 2 and ms 1

☒ **D** ir 2 and ms 2

(Total for Question 16 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

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

17 The enthalpy change of combustion of butane can be represented by the equation shown.

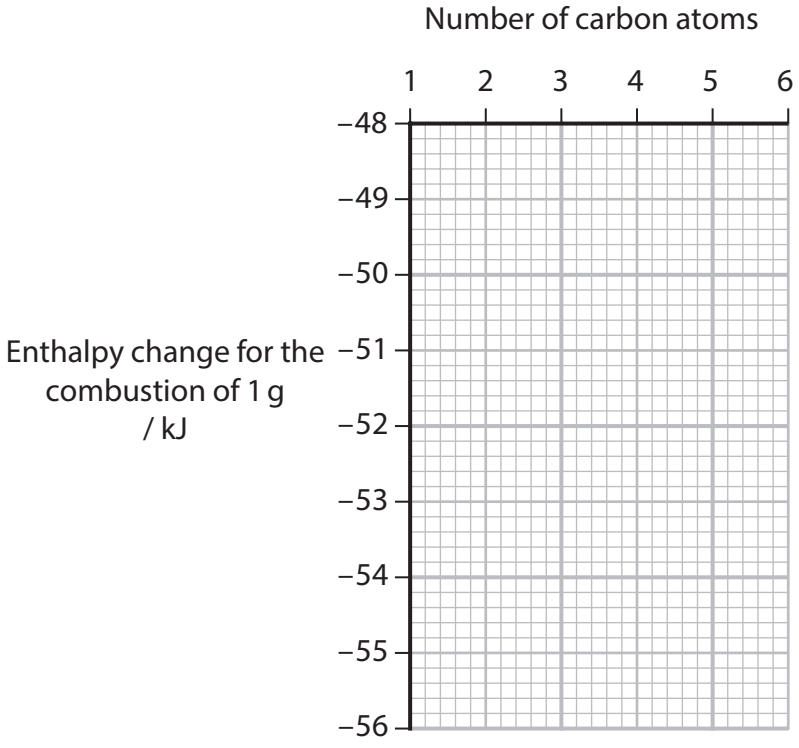
$$C_4H_{10} + 6\frac{1}{2}O_2 \rightarrow 4CO_2 + 5H_2O$$

Another useful value when considering the combustion of alkanes is the enthalpy change for the combustion of 1 g of alkane.
The table gives values for enthalpy changes of some alkanes.

	methane	ethane	propane	butane	pentane	hexane
Enthalpy change of combustion / kJ mol^{-1}	–890	–1560	–2219		–3509	–4163
Enthalpy change for combustion of 1 g / kJ	–55.6	–52.0	–50.4		–48.7	–48.4

(a) Plot a graph of the enthalpy change for the combustion of 1 g of the alkane against the number of carbon atoms in the alkane.

(2)



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(b) Complete the table for the values of butane by using your graph.
You **must** show your working.

(2)

(c) A graph of the enthalpy change of combustion against the number of carbon atoms is approximately a straight line from ethane to hexane.

Explain this statement by considering the bonds broken and made in the combustion of alkanes.

(2)

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(Total for Question 17 = 6 marks)

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18 This question is about bromine molecules and bromide ions.

(a) Explain why bromine has a lower electronegativity than chlorine but a higher electronegativity than selenium.

(3)

(b) Bromide ions may be identified using chemical reactions.

State what you would observe for each reaction given.
Include an ionic equation with state symbols where indicated.

(i) Aqueous silver nitrate is added to aqueous bromide ions, followed by the addition of concentrated aqueous ammonia.

(3)

Observation with aqueous silver nitrate

Ionic equation

Observation with concentrated aqueous ammonia

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(ii) Concentrated sulfuric acid is added to solid potassium bromide.

(2)

Two observations

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(iii) Chlorine gas is bubbled through a dilute solution containing aqueous bromide ions.

(2)

Observation

.....

Ionic equation

(c) 0.250 mol of chlorine gas were passed through an aqueous solution containing both 0.330 mol of potassium bromide and 0.330 mol of potassium iodide.

Calculate the number of moles of bromine and the number of moles of iodine produced, assuming all the chlorine has reacted.

(2)

(Total for Question 18 = 12 marks)

19 Iodine monochloride, ICl, is formed by reacting chlorine with iodine. It is a polar molecule which undergoes an addition reaction with alkenes in a similar way to hydrogen chloride.
ICl has a boiling temperature of 98 °C.

(a) In each molecule, iodine monochloride has many more electrons than water.

Explain, using intermolecular forces, why iodine monochloride has a very similar boiling temperature to water, despite having many more electrons.

(3)

(b) The reaction between iodine gas and chlorine gas is shown.

$$I_2(g) + Cl_2(g) \rightarrow 2ICl(g) \qquad \Delta H = -30\,kJ\,mol^{-1}$$

(i) Calculate the I—Cl bond enthalpy.

[Data: Bond enthalpies: I—I = +151 kJ mol^{-1} Cl—Cl = +243 kJ mol^{-1}]

(2)

(ii) Iodine and iodine monochloride are solids at standard temperature and pressure.

Calculate the enthalpy change of formation of iodine monochloride, $\Delta_f H$, using a Hess's law cycle and the data shown.

[Data: $I_2(g) + Cl_2(g) \rightarrow 2ICl(g)$ $\Delta H = -30\,kJ\,mol^{-1}$

$I_2(s) \rightarrow I_2(g)$ $\Delta H = +62\,kJ\,mol^{-1}$

$2ICl(g) \rightarrow 2ICl(s)$ $\Delta H = -102\,kJ\,mol^{-1}$]

(3)

(Total for Question 19 = 8 marks)

20 Group 2 carbonates thermally decompose to produce metal oxides.
The equation for this reaction for **Q**, representing any Group 2 element from magnesium to strontium, is shown.

$$\mathbf{Q}CO_3 \rightarrow \mathbf{Q}O + CO_2$$

(a) Explain why magnesium carbonate decomposes at a lower temperature than strontium carbonate.

(3)

*(b) A specimen tube contains a sample of an unknown Group 2 carbonate, $\mathbf{Q}CO_3$.
You are provided with a test tube, a Bunsen burner and a balance.

Devise an experiment to find the relative atomic mass of **Q** using this equipment, and hence identify the Group 2 element in the carbonate.

You should include a description of the procedure you would use and an explanation of how the results would be used to identify **Q**.

(6)

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(c) The identity of **Q** in a sample of the carbonate $\mathbf{Q}CO_3$ can also be found using a titration method.
A 1.00 g sample of $\mathbf{Q}CO_3$ was reacted with 50 cm^3 of 0.400 mol dm^{-3} hydrochloric acid.
When all the carbonate had reacted, the excess hydrochloric acid was titrated with 0.200 mol dm^{-3} sodium hydroxide solution.
The titre was 32.25 cm^3.

Identify the element **Q**. You **must** show all your working.

(5)

(Total for Question 20 = 14 marks)

TOTAL FOR SECTION B = 40 MARKS

SECTION C

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

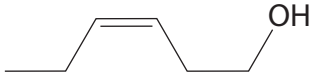
21 The smell of freshly cut grass is caused by the release of volatile organic compounds. The most important contributors to this smell are alcohols and aldehydes, both saturated and unsaturated, which contain six carbon atoms.

The compound *Z*-hex-3-enal, one of the major components of the smell of cut grass, is also released by ripe tomatoes. It easily and rapidly converts to an isomer, *E*-hex-2-enal, resulting in the rapid fading of the smell of cut grass.

Z-Hex-3-en-1-ol, produced in smaller quantities than *Z*-hex-3-enal, has a similar smell, though less intense. *Z*-Hex-3-en-1-ol has important uses in fruit and vegetable flavourings and perfumes.

(a) Complete the table.

(2)

Skeletal structure of *Z*-hex-3-en-1-ol	Skeletal structure of *Z*-hex-3-enal	Skeletal structure of *E*-hex-2-enal
		

(b) Explain why *Z*-hex-3-enal and *E*-hex-2-enal are structural isomers but not geometric isomers.

(2)

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(c) The functional groups in *Z*-hex-3-en-1-ol can be identified by chemical tests.

(i) The presence of the double bond can be identified by the addition of bromine water.

Give the skeletal formula of a possible product of this reaction.

(1)

(ii) Give a test for the presence of the –OH group in *Z*-hex-3-en-1-ol and the expected observation.

(2)

(d) Describe in outline the technique for converting an alcohol such as *Z*-hex-3-en-1-ol into an aldehyde such as *Z*-hex-3-enal in a laboratory. You may include a diagram.

(3)

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(e) Saturated non-cyclic alcohols with six carbon atoms can be classified as one of three types.

Explain these **three** types of alcohols, giving an example of each.

(4)

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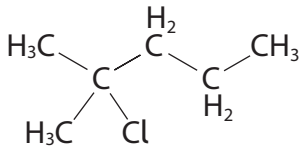
(f) The chloroalkane with six carbon atoms shown can be converted into an alcohol using potassium hydroxide.



(i) Complete the equation for this reaction. State symbols are not required.

(1)

$(CH_3)_2CClCH_2CH_2CH_3$ + ... → ..... + ...

(ii) State the role of the hydroxide ion in this reaction.

(1)

.....

(iii) Using potassium hydroxide under different conditions results in the conversion of the chloroalkane into a mixture of two alkenes.

State the condition needed for the reaction in (f)(i) to produce an alcohol and the different condition needed to produce a mixture of alkenes.

(2)

Condition to produce an alcohol

.....

Condition to produce a mixture of alkenes

.....

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(iv) Explain why two alkenes are formed in the reaction in (f)(ii).

(2)

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(Total for Question 21 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
																	(18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series

* Actinide series

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103