GradeMax

Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Monday 11 May 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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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 is an ionic equation?

☒ **A** $MgO(s) + 2CH_3COO^-(aq) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + 2CH_3COO^-(aq) + H_2O(l)$

☒ **B** $2NH_3(aq) + 2H^+(aq) + SO_4^{2-}(aq) \rightarrow 2NH_4^+(aq) + SO_4^{2-}(aq)$

☒ **C** $2Ag^+(aq) + 2NO_3^-(aq) + 2K^+(aq) + CrO_4^{2-}(aq) \rightarrow Ag_2CrO_4(s) + 2K^+(aq) + 2NO_3^-(aq)$

☒ **D** $HCO_3^-(aq) + H^+(aq) \rightarrow CO_2(g) + H_2O(l)$

(Total for Question 1 = 1 mark)

2 Which compound forms hydrogen bonds in the liquid state?

☒ **A** ammonia

☒ **B** hydrogen chloride

☒ **C** hydrogen cyanide

☒ **D** methane

(Total for Question 2 = 1 mark)

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3 Which substance has permanent dipole-permanent dipole interactions?

- ☒ **A** chloromethane
- ☒ **B** ethene
- ☒ **C** sulfur hexafluoride
- ☒ **D** tetrachloromethane

(Total for Question 3 = 1 mark)

4 What is the oxidation number of oxygen in a molecule of hydrogen peroxide, H_2O_2?

- ☒ **A** −2
- ☒ **B** −1
- ☒ **C** 0
- ☒ **D** +2

(Total for Question 4 = 1 mark)

5 How do the oxidation numbers of carbon, hydrogen and oxygen change during the complete combustion of methane?

	Carbon	Hydrogen	Oxygen
☒ **A**	increase	increase	decrease
☒ **B**	increase	no change	decrease
☒ **C**	decrease	no change	increase
☒ **D**	decrease	decrease	increase

(Total for Question 5 = 1 mark)

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6 Nitrogen reacts with hydrogen and the equilibrium shown is established.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

The volume of the container is increased at constant temperature.

How does the system change?

	Change in pressure	Equilibrium position shift
☒ **A**	decrease	left
☒ **B**	increase	left
☒ **C**	decrease	right
☒ **D**	increase	right

(Total for Question 6 = 1 mark)

7 Which is **not** an important property for a primary standard in an aqueous acid-base titration?

☒ **A** forms stable solutions

☒ **B** high solubility in water

☒ **C** low molar mass

☒ **D** reacts rapidly and completely when used in titrations

(Total for Question 7 = 1 mark)

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8 The titration results of four students are shown.

	Titre / cm^3				
	Rough	1	2	3	Mean of concordant results
Student 1	24.40	24.20	24.15	24.10	24.15
Student 2	24.35	23.65	24.10	24.00	24.05
Student 3	24.65	23.40	23.80	23.70	23.75
Student 4	24.20	23.05	23.85	23.95	23.90

The true titre value is 24.00 cm^3.

(a) Which student has the most accurate mean titre?

(1)

☒ **A** Student 1

☒ **B** Student 2

☒ **C** Student 3

☒ **D** Student 4

(b) Which student has the most precise titres?

(1)

☒ **A** Student 1

☒ **B** Student 2

☒ **C** Student 3

☒ **D** Student 4

(Total for Question 8 = 2 marks)

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9 A student tested an unknown gas in the laboratory.

The gas extinguished a lighted splint, turned limewater cloudy and turned blue litmus solution red.

Which could be the gas tested?

- ☒ **A** ammonia
- ☒ **B** carbon dioxide
- ☒ **C** nitrogen dioxide
- ☒ **D** sulfur dioxide

(Total for Question 9 = 1 mark)

10 In which solid are **only** London forces broken on melting?

- ☒ **A** diamond
- ☒ **B** magnesium oxide
- ☒ **C** poly(ethene)
- ☒ **D** silver

(Total for Question 10 = 1 mark)

11 Which standard enthalpy change does not necessarily refer to one mole of substance?

- ☒ **A** $\Delta_c H^{\ominus}$
- ☒ **B** $\Delta_f H^{\ominus}$
- ☒ **C** $\Delta_r H^{\ominus}$
- ☒ **D** $\Delta_{neut} H^{\ominus}$

(Total for Question 11 = 1 mark)

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12 Catalysts are often used to improve the sustainability of an industrial process.

A student suggested three benefits of using a catalyst:

I catalysts always increase atom economy to 100%
II catalysts always increase the rate of reaction
III catalysts always decrease energy consumption

Which of the student's suggestions are correct?

☒ **A** I and II

☒ **B** I and III

☒ **C** I, II and III

☒ **D** II and III

(Total for Question 12 = 1 mark)

13 Which species can act as a nucleophile?

☒ **A** NH_4^+

☒ **B** Cl_2

☒ **C** NH_3

☒ **D** CO_2

(Total for Question 13 = 1 mark)

14 How many structural isomers have the molecular formula C_4H_9Br?

☒ **A** 2

☒ **B** 3

☒ **C** 4

☒ **D** 5

(Total for Question 14 = 1 mark)

15 Which is a redox reaction?

☒ **A** $C_2H_4 + H_2 \rightarrow C_2H_6$

☒ **B** $HCl + NaOH \rightarrow NaCl + H_2O$

☒ **C** $(CH_3)_3COH + HCl \rightarrow (CH_3)_3CCl + H_2O$

☒ **D** $CaO + SiO_2 \rightarrow CaSiO_3$

(Total for Question 15 = 1 mark)

16 Some properties of five substances are shown.

Substance	Solubility in water	Solution pH
V	slightly soluble	12.4
W	very soluble	7.0
X	slightly soluble	7.0
Y	reacts to form a solution	12.4
Z	insoluble	no solution

Use the information in the table to answer the questions.

(a) Which substance could be calcium?

(1)

- ☒ **A V**
- ☒ **B W**
- ☒ **C X**
- ☒ **D Y**

(b) Which substance could be barium sulfate?

(1)

- ☒ **A V**
- ☒ **B W**
- ☒ **C Y**
- ☒ **D Z**

(c) Which substance could be calcium hydroxide?

(1)

- ☒ **A V**
- ☒ **B W**
- ☒ **C Y**
- ☒ **D Z**

(Total for Question 16 = 3 marks)

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17 Which isomer has the lowest boiling temperature?

- ☒ **A** $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$
- ☒ **B** $CH_3CH(CH_3)CH_2CH_2CH_2CH_2CH_2CH_3$
- ☒ **C** $(CH_3)_3CCH_2CH_2CH_2CH_2CH_3$
- ☒ **D** $CH_3CH_2C(CH_3)_2CH_2CH(CH_3)CH_3$

(Total for Question 17 = 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.

18 This question is about halogens and halide ions.

(a) When chlorine reacts with sodium hydroxide, the products depend on the conditions.

(i) Write the equation for the reaction between chlorine and cold aqueous sodium hydroxide.
State symbols are not required.

(1)

(ii) The equation for the reaction between chlorine and hot concentrated aqueous sodium hydroxide is shown.

$$Cl_2 + 6NaOH \rightarrow 5NaCl + NaClO_3 + 3H_2O$$

Explain, in terms of oxidation numbers, what is meant by disproportionation, using this reaction as an example.

(2)

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(b) When bromine reacts with sodium hydroxide, a compound is formed that contains sodium, bromine and oxygen.
The percentage by mass of sodium is 15.3% and bromine is 52.9%.

Calculate the empirical formula of this compound.
You **must** show your working.

(3)

(c) When concentrated sulfuric acid is added to solid sodium iodide, several reactions occur.

(i) Reaction 1

$$NaI + H_2SO_4 \rightarrow NaHSO_4 + HI$$

State how the iodide ion acts in this reaction.

(1)

.....

(ii) Reaction 2

Hydrogen iodide reacts further to produce iodine and a gas with a 'bad egg' smell.
Identify the classification of this type of reaction.

(1)

.....

(iii) Reaction 3

In another reaction, hydrogen iodide produces iodine and a yellow solid.
Write a balanced equation for this reaction.

(2)

(Total for Question 18 = 10 marks)

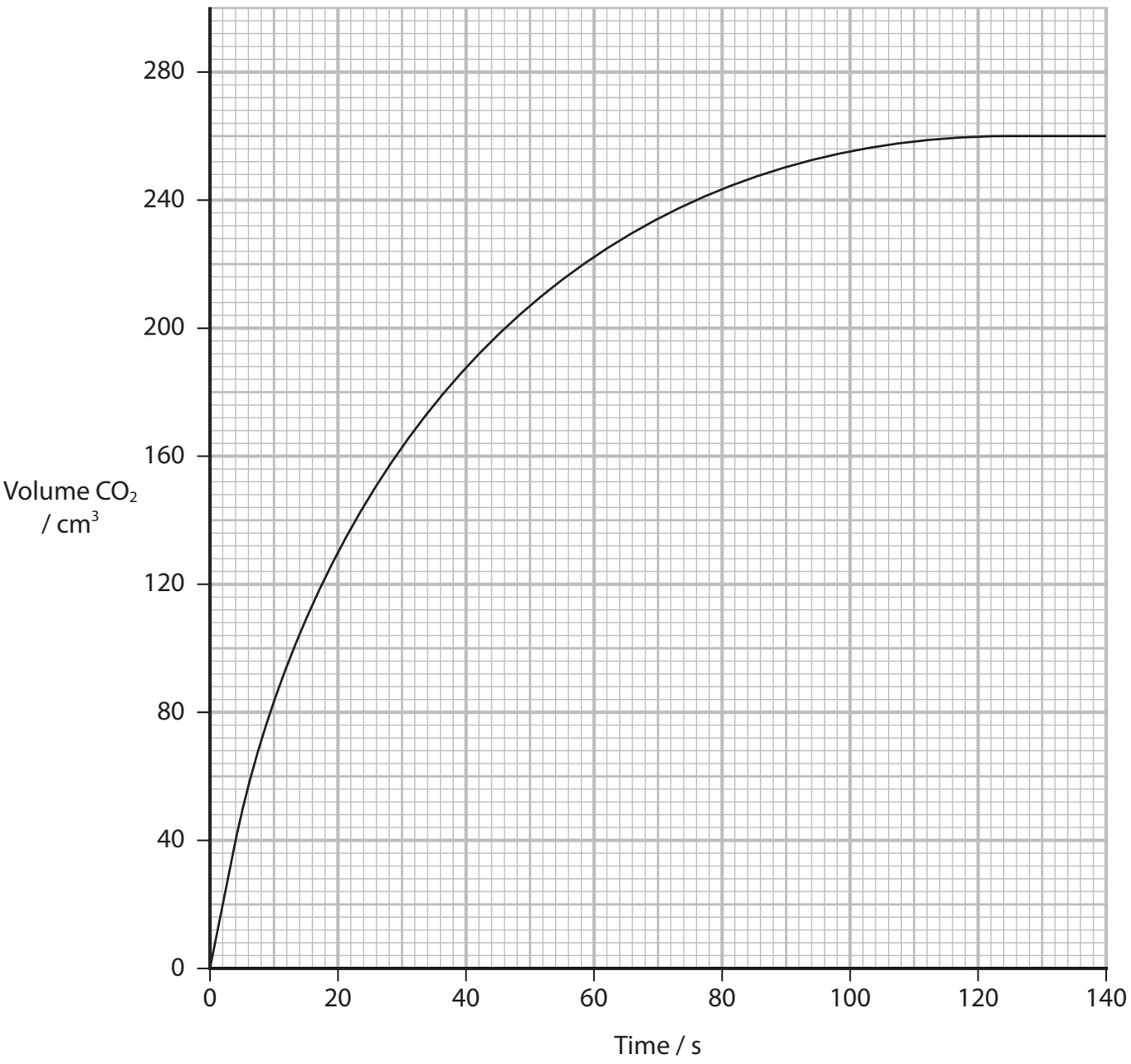
19 This question is about Group 2 compounds.

(a) Calcium carbonate, as marble, is used to make statues. The features on these statues can be damaged by acid rain.

Give the **formula** of an acid present in acid rain.

(1)

(b) The reaction between marble chips and hydrochloric acid is used to investigate rates of reaction. A graph for the reaction is shown.



(i) Calculate the **initial** rate of reaction by drawing a tangent on the graph. Include units in your answer. You **must** show your working.

(3)

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(ii) The experiment was repeated with the only change being the use of larger marble chips of the same total mass.
Draw a line on the graph for this second reaction. Justify your answer.

(3)

(c) Explain the trend in thermal stability of the Group 2 carbonates going **down** the group.

(3)

(d) Calcium oxide reacts with water to form limewater, a saturated solution of calcium hydroxide.

(i) 25.0 cm^3 portions of limewater, at 20 °C, were titrated with 0.0500 mol dm^{-3} hydrochloric acid. The mean titre was 23.35 cm^3.

The equation for the reaction is shown.

$$Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$$

Calculate the mass, in g, of calcium hydroxide in 100 cm^3 of limewater at 20 °C. Give your answer to **three** significant figures.

(4)

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(ii) Calcium hydroxide is 34.5% **less** soluble at 70 °C than at 20 °C.

Calculate the concentration of calcium hydroxide, in mol dm^{-3}, at 70 °C.

(2)

(Total for Question 19 = 16 marks)

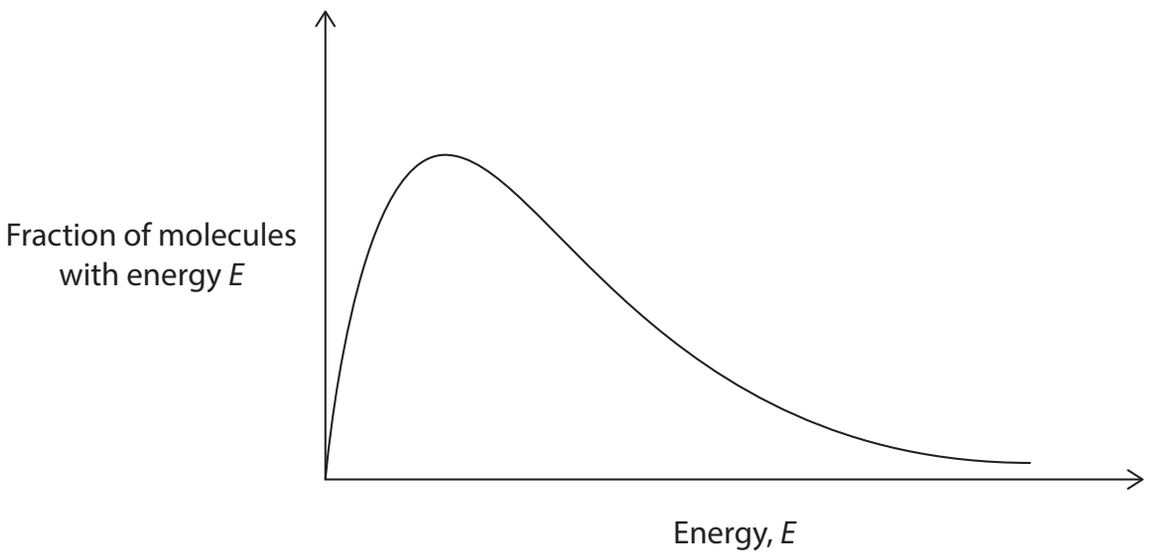
20 Hydrogen halides are gaseous compounds.

(a) Hydrogen and chlorine gases react together to form hydrogen chloride.

(i) A Maxwell–Boltzmann distribution for this reaction at 20 °C is shown.

Draw on the same axes a Maxwell–Boltzmann distribution for the reaction mixture at 30 °C, and a labelled line for the activation energy.

(2)



(ii) Explain, using the Maxwell–Boltzmann distributions, why the rate of reaction increases at higher temperatures.

(2)

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(b) Explain why the boiling temperature of hydrogen iodide is higher than that of hydrogen chloride, but lower than that of hydrogen fluoride.

Detailed explanations of intermolecular forces are not required.

(4)

(Total for Question 20 = 8 marks)

***21** Describe how four different organic compounds can be produced by reacting 2-bromobutane with potassium hydroxide under different conditions.

Refer to the types of reaction and the different types of isomerism that occur.

Detailed explanations of reaction mechanisms and practical procedures are not required.

(6)

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(Total for Question 21 = 6 marks)

TOTAL FOR SECTION B = 40 MARKS

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SECTION C

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

22 Alcohols have a variety of uses.
Ethanol is used as a solvent for perfumes.
Ethanol and propan-2-ol have been used as antiseptics for some time and are now also used to make hand sanitiser gel.
The combustion of ethanol has been used as a source of energy for many years.
More recently, ethanol and methanol have been used in fuel cells, which produce electrical energy.

(a) Suggest **two** reasons why ethanol is a good solvent for perfume.

(2)

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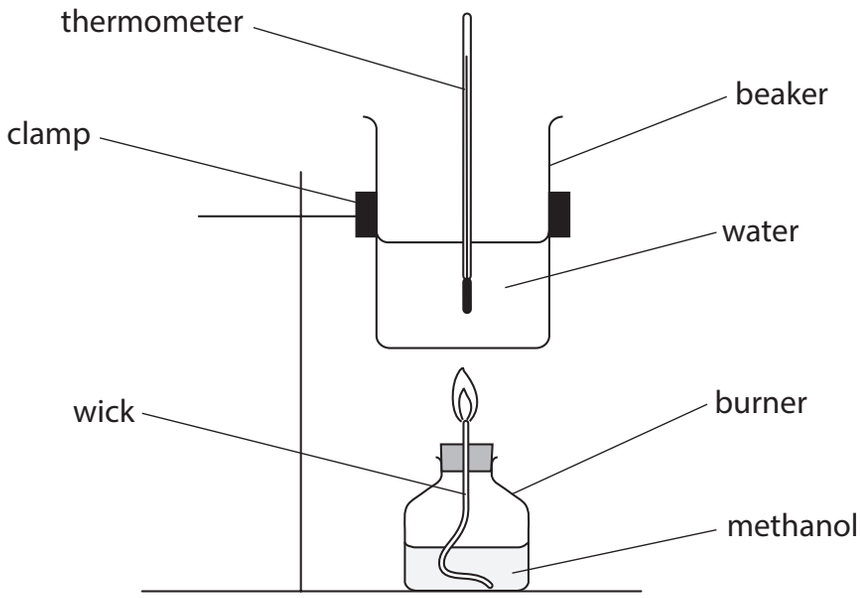
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(b) (i) Write the equation for the standard enthalpy change of combustion for methanol. Include state symbols.

(1)

(ii) The enthalpy change of combustion of methanol was determined using the apparatus shown.



The results of the experiment are shown.

Measurement	Value
Mass of water / g	150
Mass of methanol burned / g	0.260
Starting temperature / °C	22.2
Maximum temperature / °C	26.9

Calculate the enthalpy change of combustion, in $kJ\,mol^{-1}$, for methanol.

Give your answer to an appropriate number of significant figures.
Include a sign.

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

(4)

(iii) Give a **major** reason why this experimental value is different from the Data Booklet value for the standard enthalpy change of combustion for methanol.

(1)

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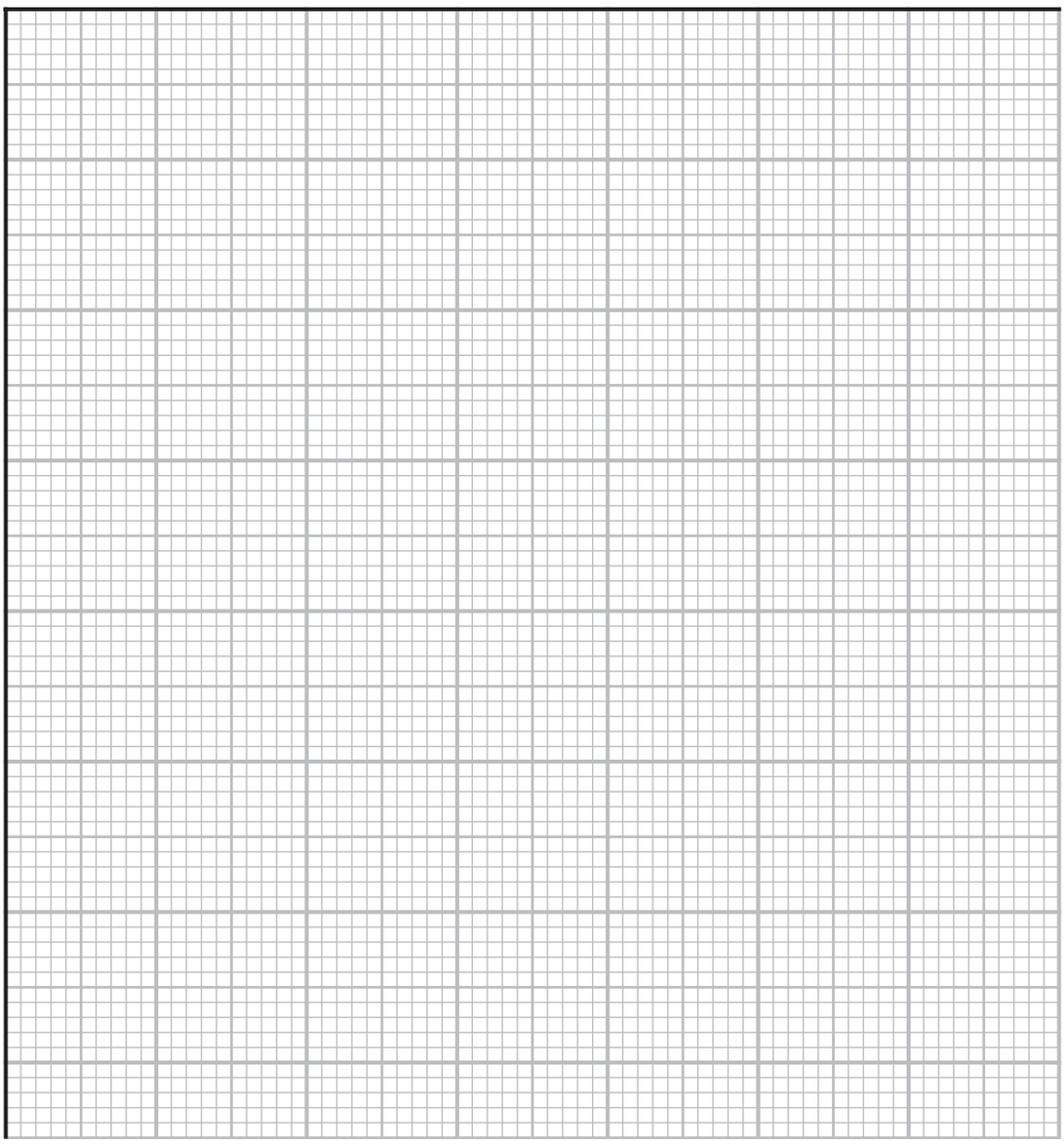
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(iv) The standard enthalpy change of combustion for straight-chain primary alcohols is shown in the table.

Number of carbon atoms	2	3	4	5	6	7	8
Standard enthalpy change of combustion / kJ mol^{-1}	−1367	−2021	−2676	−3329	−3984		−5294

Plot a graph of standard enthalpy change of combustion against the number of carbon atoms.

(3)



(v) Determine the standard enthalpy change of combustion for heptan-1-ol, using your graph.

(1)

.....

(c) Alcohols can be oxidised by acidified potassium dichromate(VI).

(i) The equilibrium between chromate(VI) and dichromate(VI) ions is shown.

$$\underset{\text{yellow}}{2CrO_4^{2-}(aq)} + 2H^+(aq) \rightleftharpoons \underset{\text{orange}}{Cr_2O_7^{2-}(aq)} + H_2O(l) \qquad \Delta H \text{ positive}$$

State what would be observed when an orange equilibrium mixture containing these ions is cooled from 50 °C to 5 °C.
Justify your answer.

(2)

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.....

(ii) A student heats a mixture of propan-1-ol and acidified potassium dichromate(VI) in a distillation apparatus.

Draw the **skeletal** formula of the organic product that distils from the mixture as the reaction occurs.

(1)

(iii) A student heats under reflux a fresh mixture of propan-1-ol and acidified potassium dichromate(VI).

The organic products from both (ii) and (iii) were analysed.

Describe how these products can be distinguished using infrared spectroscopy.
Refer to **two** types of bond stretching vibrations and their wavenumber ranges.
Use your Data Booklet.

(2)

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(iv) The functional groups in the products from the oxidation of alcohols can be identified by chemical tests.

Complete the table.

(2)

Name of functional group	Test	Positive result
	Warm with Fehling's or Benedict's solution	
	Add sodium carbonate solution	

(d) An aqueous solution of propan-2-ol is used to clean phone screens and lenses.

Suggest **one** reason why an aqueous solution is used and not the pure alcohol.

(1)

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(Total for Question 22 = 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)											(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											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							

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

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

* Lanthanide series

* Actinide series

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