CAMBRIDGE
International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **9701/23**

Paper 2 AS Level Structured Questions **May/June 2026**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen. Do **not** use correction fluid or tape.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 60.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.
- Important values, constants and standards are printed in the question paper.

This document has **16** pages. Any blank pages are indicated.

DC (ST/CB) 353882/3

[Turn over

1 The chlorides of Period 3 elements show different physical and chemical properties.

(a) (i) Complete Table 1.1.

Table 1.1

element	formula of chloride	type of bonding in the chloride	type of reaction, if any, of the chloride with cold water
sodium			
silicon			

[3]

(ii) Write an equation for the reaction of PCl_5 with an excess of cold water.

..... [1]

(b) The reaction of chlorine with cold water is used in water purification.

(i) Write an equation for the reaction of chlorine with cold water.

..... [1]

(ii) Explain the use of chlorine in water purification.

.....

..... [1]

(c) The relative strength of Cl_2, Br_2 and I_2 as oxidising agents can be compared by adding NaBr(aq) to separate samples of Cl_2 and I_2.

(i) Describe the relative reactivity of Cl_2, Br_2 and I_2 as oxidising agents.

.....

.....

..... [1]

(ii) Complete Table 1.2 to describe the reactions of NaBr(aq) with separate samples of Cl_2(aq) and I_2(aq).

Table 1.2

aqueous halogen	colour of aqueous halogen	appearance after NaBr(aq) is added	halide ions present in the mixture after the reaction
Cl_2(aq)	pale green		
I_2(aq)	red–brown		

[3]

(d) Describe what is observed when Ag^+(aq), followed by NH_3(aq), are added to a sample of NaI(aq).

observation after addition of Ag^+(aq) .....

observation after addition of NH_3(aq) .....

[2]

[Total: 12]

2 Group 18 elements exist as colourless gases at room temperature and pressure.

Table 2.1

atom	relative volume of atom
neon	172
argon	287
krypton	355
xenon	446

(a) Use Table 2.1 to describe and explain the variation in atomic radius down Group 18.

.....

.....

.....

..... [2]

(b) Identify **one** Group 18 element from Table 2.1 that behaves most like an ideal gas under standard conditions. Explain your answer.

.....

.....

.....

..... [3]

(c) A sample of 1.775 g of gas **X** occupies 617.0 cm^3 at 300 K and 101 kPa.

Calculate the relative molecular mass, M_r, of **X** assuming that **X** behaves as an ideal gas.

M_r of **X** = ... [4]

[Total: 9]

3 The conditions used for the conversion of sulfur dioxide to sulfur trioxide in the Contact process are carefully controlled.

reaction 1 $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ $\Delta H = -196\,kJ\,mol^{-1}$

(a) Complete Figure 3.1 to show the reaction pathway diagram for reaction 1.

Draw arrows to represent the enthalpy change, ΔH, and activation energy, E_A.

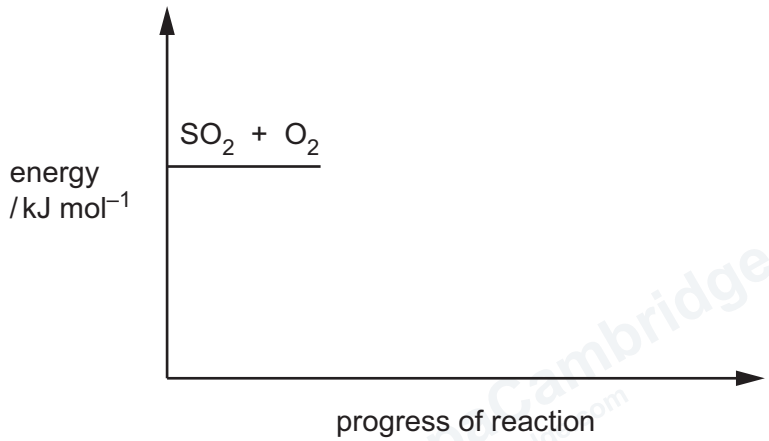

Figure 3.1

[2]

(b) Define Le Chatelier's principle.

.....

.....

..... [2]

(c) In industry, reaction 1 occurs at 400–450 °C and 110–200 kPa with a catalyst.

Complete Table 3.1 by using the terms 'increase', 'decrease' or 'no change'.

Table 3.1

	use temperature greater than 450 °C	**without catalyst**
effect on value of equilibrium constant, K_p		
effect on yield of product at equilibrium		
effect on rate of reaction		

[3]

(d) A sealed tube that initially contains only 2.00 mol of $SO_2(g)$ and 2.00 mol of $O_2(g)$ is left to reach equilibrium.

At equilibrium, 1.96 mol of $SO_3(g)$ is present and the total pressure is 150 kPa.

reaction 1 $\quad 2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

(i) Complete Table 3.2.

Table 3.2

	$SO_2(g)$	$O_2(g)$	$SO_3(g)$
amount initially / mol	2.00	2.00	0
amount at equilibrium / mol			1.96
mole fraction at equilibrium	0.01325	0.3377	

[3]

(ii) Table 3.3 shows the mole fractions at equilibrium of $SO_2(g)$, $O_2(g)$ and $SO_3(g)$ under different conditions.

Table 3.3

	$SO_2(g)$	$O_2(g)$	$SO_3(g)$
mole fraction at equilibrium	0.360	0.019	0.621

Calculate K_p at 200 kPa using the data from Table 3.3.

Include units in your answer.

K_p = ...

units .....

[3]

[Total: 13]

4 The structure of compound **V** is shown in Figure 4.1.

V

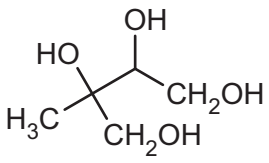

Figure 4.1

(a) (i) Complete Table 4.1.

Table 4.1

	primary hydroxyl groups	**secondary hydroxyl groups**	**tertiary hydroxyl groups**
number of groups in one molecule of V			

[2]

(ii) Complete Table 4.2 to show what is observed when separate samples of **V** are added to each reagent. State 'none' if no reaction occurs.

Table 4.2

reagent	**observation with V**
Na(s)	
2,4-dinitrophenylhydrazine (2,4-DNPH)	
Fehling's reagent	none

[2]

(iii) Suggest why Fehling's reagent does **not** react with **V** but does react with aldehyde functional groups.

.....

.....

..... [1]

(b) Figure 4.1 is repeated for use in **4(b)**.

V

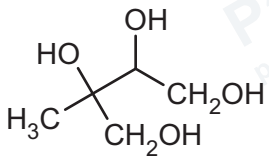

Figure 4.1

V is completely oxidised by heating under reflux with an excess of acidified $K_2Cr_2O_7$(aq) to produce organic compound **Z**.

(i) Describe the colour change in this reaction.

colour of mixture at start of the reaction .....

colour of mixture after the reaction .....

[1]

(ii) Draw the structure of **Z**.

[1]

(c) Compounds **W**, **X** and **Y** are structural isomers of **V**.

V **W** **X** **Y**

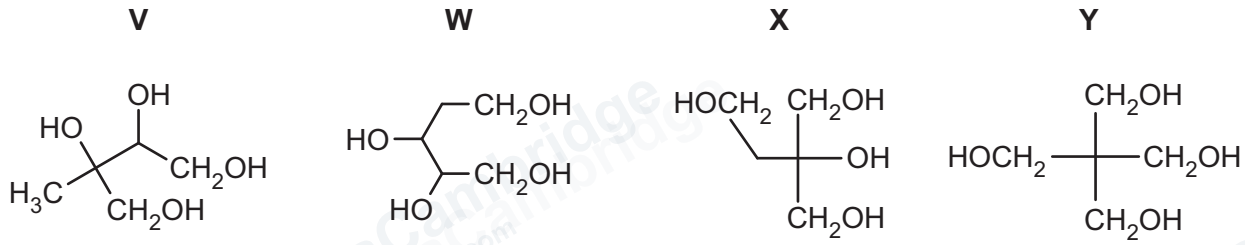

Figure 4.2

(i) Describe structural isomerism.

.....

.....

..... [2]

(ii) Identify which of structures **V**, **W**, **X** and **Y** show stereoisomerism.

Explain your answer by referring to the relevant parts of the molecule that cause stereoisomerism.

.....

.....

..... [2]

(iii) **Y** reacts with reagent **R** to produce compound **E**.

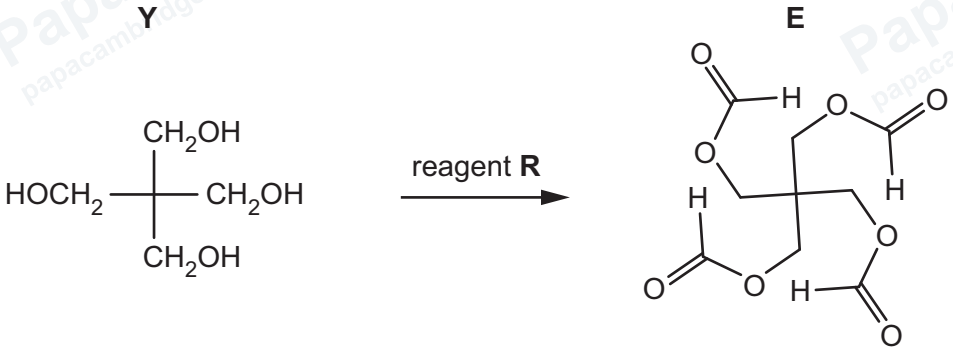

Figure 4.3

Name reagent **R**.

..... [1]

(d) Exactly 0.03 mol of one of the isomers, **V**, **W**, **X** or **Y**, is completely oxidised by 0.08 mol of acidified $K_2Cr_2O_7$(aq) to produce only **one** organic compound with molecular formula $C_5H_4O_8$.

(i) Identify which isomer, **V**, **W**, **X** or **Y**, is used in this reaction.

..... [1]

(ii) Complete the equation for this reaction.

$3C_5H_{12}O_4$ + ...$Cr_2O_7^{2-}$ + ...H^+ → $3C_5H_4O_8$ + ...Cr^{3+} + ...H_2O [1]

[Total: 14]

5 Propane, $CH_3CH_2CH_3$, reacts with $Cl_2(g)$ in the presence of ultraviolet light to produce different organic products, including those shown in Table 5.1.

Table 5.1

structure of product	systematic name of product
$CH_3(CH_2)_2Cl$	1-chloropropane
$CH_3CHClCH_3$	2-chloropropane
$(CH_3)_2CHCH(CH_3)_2$	2,3-dimethylbutane
	hexane
	2-methylpentane

(a) (i) Complete Table 5.1. [2]

(ii) Name the mechanism for the reaction of propane and $Cl_2(g)$ in the presence of ultraviolet light.

..... [1]

(b) The mechanism for this reaction involves three stages.

stage 1 initiation
stage 2 propagation
stage 3 termination

During the initiation reaction, a chlorine free radical is produced.

(i) Complete Figure 5.1 to describe the arrangement of electrons in a chlorine free radical.

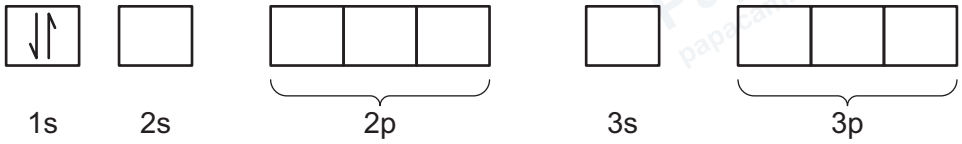

Figure 5.1

[1]

(ii) Suggest a reaction sequence of **two** propagation reactions that result in $CH_3CH_2CH_3$ forming $CH_3CH_2CH_2Cl$.

propagation reaction 1

$CH_3CH_2CH_3$ ..... → .....

propagation reaction 2

..... → $CH_3CH_2CH_2Cl$ .....

[2]

(iii) Suggest a reaction sequence of **one** propagation reaction followed by a termination reaction that results in $CH_3CH_2CH_3$ forming $(CH_3)_2CHCH(CH_3)_2$.

propagation reaction 3

$CH_3CH_2CH_3$ ..... → .....

termination reaction

..... → $(CH_3)_2CHCH(CH_3)_2$

[2]

(c) Compound **A** has the molecular formula CH_2Cl_2. Figure 5.2 shows the mass spectrum of **A**.

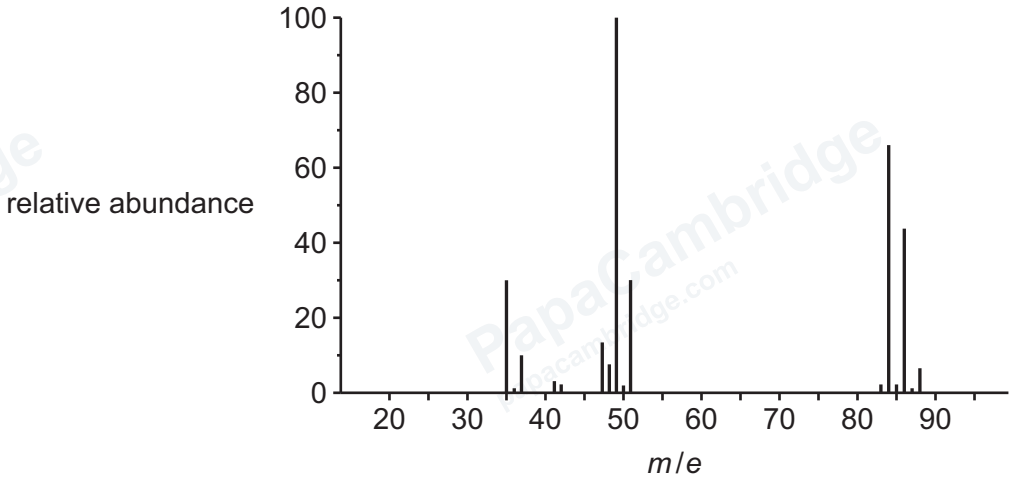

Figure 5.2

(i) Explain the difference in relative abundance of the peaks at m/e = 35 and m/e = 37.

.....

..... [2]

(ii) Complete Table 5.2.

Table 5.2

m/e value of peak	molecular formula of species responsible for peak
84	
86	
88	

[2]

[Total: 12]

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Important values, constants and standards

molar gas constant	$R = 8.31\,\text{J K}^{-1}\,\text{mol}^{-1}$
Faraday constant	$F = 9.65 \times 10^{4}\,\text{C mol}^{-1}$
Avogadro constant	$L = 6.022 \times 10^{23}\,\text{mol}^{-1}$
electronic charge	$e = -1.60 \times 10^{-19}\,\text{C}$
molar volume of gas	$V_m = 22.4\,\text{dm}^3\,\text{mol}^{-1}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0\,\text{dm}^3\,\text{mol}^{-1}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14}\,\text{mol}^2\,\text{dm}^{-6}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18\,\text{kJ kg}^{-1}\,\text{K}^{-1}$ ($4.18\,\text{J g}^{-1}\,\text{K}^{-1}$)

The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
							1 H hydrogen 1.0										2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0											5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
11 Na sodium 23.0	12 Mg magnesium 24.3	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium –	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

Key

atomic number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.2	61 Pm promethium –	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.3	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.1	71 Lu lutetium 175.0
actinoids	89 Ac actinium –	90 Th thorium 232.0	91 Pa protactinium 231.0	92 U uranium 238.0	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –