



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.

- 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 $\text{Cl}_2(\text{aq})$ and $\text{I}_2(\text{aq})$.

Table 1.2

aqueous halogen	colour of aqueous halogen	appearance after NaBr(aq) is added	halide ions present in the mixture after the reaction
$\text{Cl}_2(\text{aq})$	pale green		
$\text{I}_2(\text{aq})$	red-brown		

[3]

(d) Describe what is observed when $\text{Ag}^+(\text{aq})$, followed by $\text{NH}_3(\text{aq})$, are added to a sample of NaI(aq) .

observation after addition of $\text{Ag}^+(\text{aq})$

observation after addition of $\text{NH}_3(\text{aq})$

[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 cm³ at 300 K and 101 kPa.

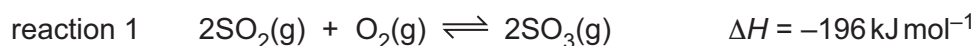
Calculate the relative molecular mass, M_r , of **X** assuming that **X** behaves as an ideal gas.

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.



- (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 .

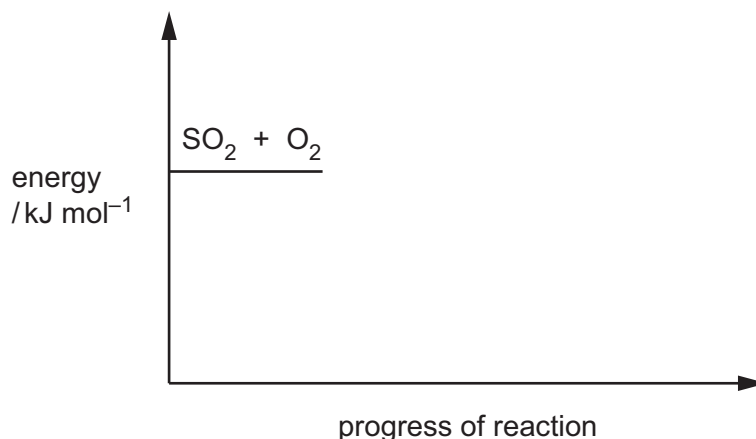


Figure 3.1

[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'.

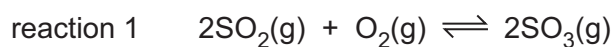
Table 3.1

	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 $\text{SO}_2(\text{g})$ and 2.00 mol of $\text{O}_2(\text{g})$ is left to reach equilibrium.

At equilibrium, 1.96 mol of $\text{SO}_3(\text{g})$ is present and the total pressure is 150 kPa.



- (i) Complete Table 3.2.

Table 3.2

	$\text{SO}_2(\text{g})$	$\text{O}_2(\text{g})$	$\text{SO}_3(\text{g})$
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 $\text{SO}_2(\text{g})$, $\text{O}_2(\text{g})$ and $\text{SO}_3(\text{g})$ under different conditions.

Table 3.3

	$\text{SO}_2(\text{g})$	$\text{O}_2(\text{g})$	$\text{SO}_3(\text{g})$
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

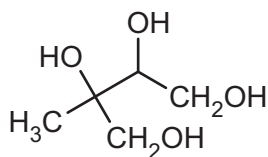


Figure 4.1

- (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

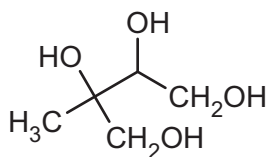


Figure 4.1

V is completely oxidised by heating under reflux with an excess of acidified $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$ 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

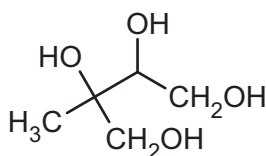
[1]

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

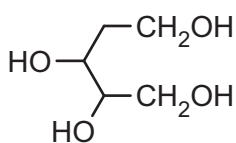
[1]

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

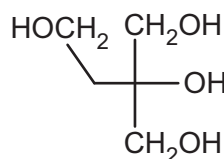
V



W



X



Y

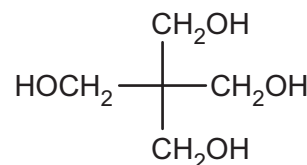


Figure 4.2

(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**.

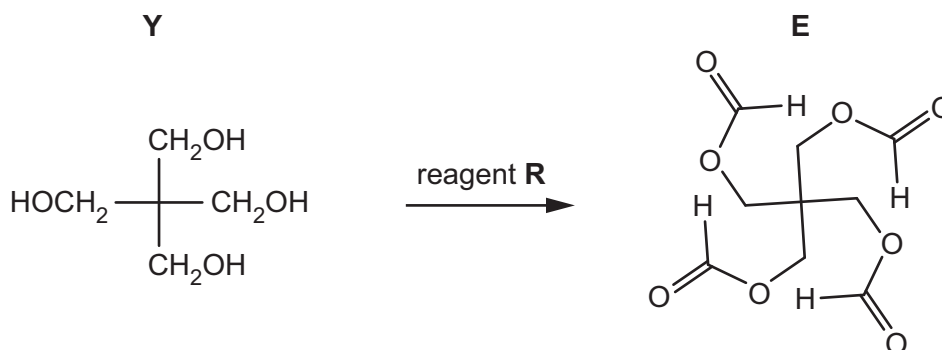


Figure 4.3

Name reagent **R**.

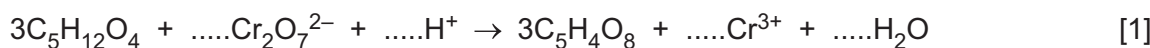
..... [1]

- (d) Exactly 0.03 mol of one of the isomers, **V**, **W**, **X** or **Y**, is completely oxidised by 0.08 mol of acidified $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq})$ to produce only **one** organic compound with molecular formula $\text{C}_5\text{H}_4\text{O}_8$.

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

..... [1]

- (ii) Complete the equation for this reaction.



[Total: 14]

- 5 Propane, $\text{CH}_3\text{CH}_2\text{CH}_3$, reacts with $\text{Cl}_2(\text{g})$ 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
$\text{CH}_3(\text{CH}_2)_2\text{Cl}$	1-chloropropane
$\text{CH}_3\text{CHClCH}_3$	2-chloropropane
$(\text{CH}_3)_2\text{CHCH}(\text{CH}_3)_2$	2,3-dimethylbutane
	hexane
	2-methylpentane

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

- (ii) Name the mechanism for the reaction of propane and $\text{Cl}_2(\text{g})$ 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.

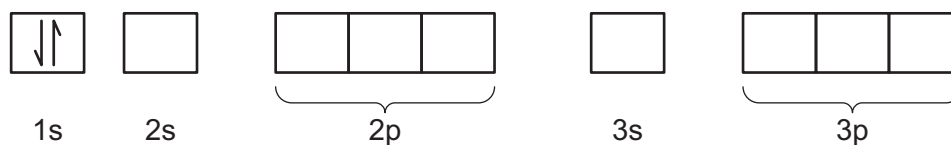
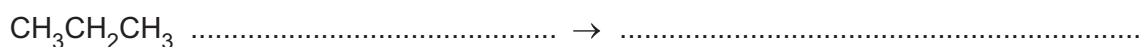


Figure 5.1

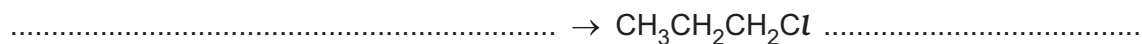
[1]

- (ii) Suggest a reaction sequence of **two** propagation reactions that result in $\text{CH}_3\text{CH}_2\text{CH}_3$ forming $\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$.

propagation reaction 1



propagation reaction 2

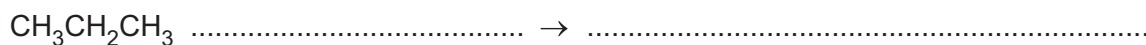


[2]



- (iii) Suggest a reaction sequence of **one** propagation reaction followed by a termination reaction that results in $\text{CH}_3\text{CH}_2\text{CH}_3$ forming $(\text{CH}_3)_2\text{CHCH}(\text{CH}_3)_2$.

propagation reaction 3



termination reaction



[2]

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

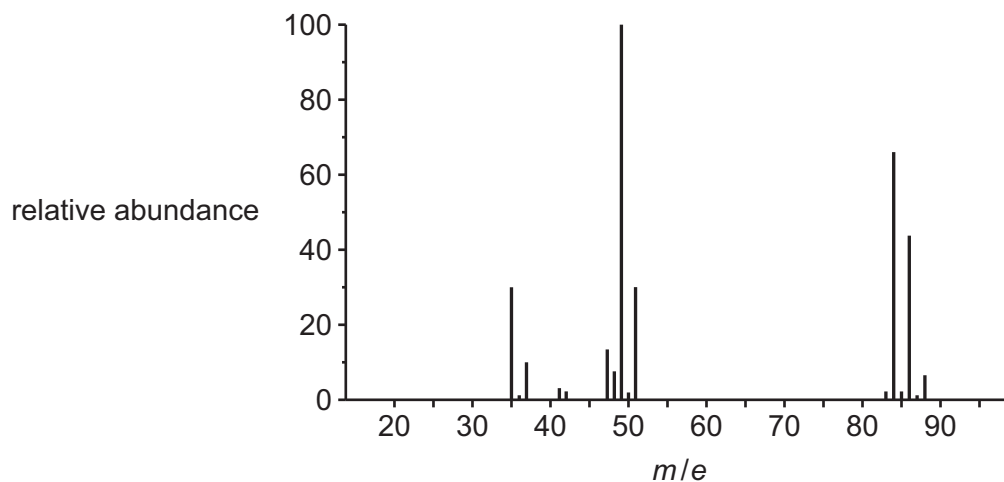


Figure 5.2

- (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

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

[2]

[Total: 12]









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 J g ⁻¹ K ⁻¹)

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (Cambridge University Press & Assessment) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in our Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at www.cambridgeinternational.org after the live examination series.

Cambridge International Education is the name of our awarding body and a part of Cambridge University Press & Assessment, which is a department of the University of Cambridge.



The Periodic Table of Elements

Group																	
1	2															17	18
		1Hhydrogen1.0															
3	Li lithium 6.9	4Be beryllium 9.0	Key atomic number atomic symbol name relative atomic mass														2He helium 4.0
	11Na sodium 23.0	12Mg magnesium 24.3	3	4	5	6	7	8	9	10	11	12	13	14	15	16	18
19K potassium 39.1	20Ca calcium 40.1	21Sc scandium 45.0	22Ti titanium 47.9	23V vanadium 50.9	24Cr chromium 52.0	25Mn manganese 54.9	26Fe iron 55.8	27Co cobalt 58.9	28Ni nickel 58.7	29Cu copper 63.5	30Zn zinc 65.4	31Ga gallium 69.7	32Ge germanium 72.6	33As arsenic 74.9	34Se selenium 79.0	35Br bromine 79.9	36Kr krypton 83.8
37Rb rubidium 85.5	38Sr strontium 87.6	39Y yttrium 88.9	40Zr zirconium 91.2	41Nb niobium 92.9	42Mo molybdenum 95.9	43Tc technetium —	44Ru ruthenium 101.1	45Rh rhodium 102.9	46Pd palladium 106.4	47Ag silver 107.9	48Cd cadmium 112.4	49In indium 114.8	50Sn tin 118.7	51Sb antimony 121.8	52Te tellurium 127.6	53I iodine 126.9	54Xe xenon 131.3
55Cs caesium 132.9	56Ba barium 137.3	57–71lanthanoids	72Hf hafnium 178.5	73Ta tantalum 180.9	74W tungsten 183.8	75Re rhenium 186.2	76Os osmium 190.2	77Ir iridium 192.2	78Pt platinum 195.1	79Au gold 197.0	80Hg mercury 200.6	81Tl thallium 204.4	82Pb lead 207.2	83Bi bismuth 209.0	84Po polonium —	85At astatine —	86Rn radon —
87Fr francium —	88Ra radium —	89–103actinoids	104Rf rutherfordium —	105Db dubnium —	106Sg seaborgium —	107Bh bohrium —	108Hs hassium —	109Mt meitnerium —	110Ds darmstadtium —	111Rg roentgenium —	112Cn copernicium —	113Nh nihonium —	114Fl flerovium —	115Mc moscovium —	116Lv livermorium —	117Ts tennessine —	118Og ognesson —

lanthanoids

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

actinoids