Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

3362778049

CHEMISTRY **9701/24**

Paper 2 AS Level Structured Questions **October/November 2025**

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 or correction fluid.
- 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.

© UCLES 2025

[Turn over

1 The Group 17 elements are oxidising agents.

(a) (i) Explain how the Group 17 elements act as oxidising agents.

.....

..... [1]

(ii) Write an equation to show the reaction in which Cl_2 oxidises aluminium metal.

..... [1]

(iii) A student heats equal amounts of $I_2(g)$ and $H_2(g)$ in a sealed flask. The student leaves the contents to cool.

State what you would observe during the reaction.

..... [1]

(b) Cl_2 and Br_2 can each react with NH_3 to give N_2 and a hydrogen halide, HX.

$$3X_2 + 2NH_3 \rightarrow N_2 + 6HX \qquad X = Cl \text{ or } Br$$

The relative bond strengths of X–X and H–X determine the difference in enthalpy change of the two reactions.

(i) Describe and explain the difference in the X–X bond strengths of Cl_2 and Br_2.

.....

.....

.....

..... [2]

(ii) Describe the relative thermal stabilities of HCl and HBr.

..... [1]

DO NOT WRITE IN THIS MARGIN

(iii) Define enthalpy change of formation, ΔH_f.

.....

.....

..... [2]

(iv) Table 1.1 gives data relevant to the reaction of $Cl_2(g)$ with $NH_3(g)$.

Table 1.1

compound	enthalpy change of formation, ΔH_f / kJ mol^{-1}
$NH_3(g)$	–46
$HCl(g)$	–92

Use the data in Table 1.1 to calculate the enthalpy change of the reaction of $Cl_2(g)$ with $NH_3(g)$.

enthalpy change of reaction = ... kJ mol^{-1} [2]

(v) I_2 reacts with NH_3 to form NI_3.

Predict the shape of a molecule of NI_3. Explain your answer.

shape .....

explanation .....

.....

[2]

DO NOT WRITE IN THIS MARGIN

(c) Table 1.2 shows some information about reactions of NaCl, NaBr and NaI.

Table 1.2

	NaCl	**NaBr**	**NaI**
observation with $Ag^+(aq)$	white precipitate		
type of reaction with concentrated H_2SO_4	acid–base	acid–base, then redox	acid–base, then redox
observations with concentrated H_2SO_4			• black solid • yellow solid • effervescence

(i) Complete Table 1.2. [4]

(ii) Suggest an identity for the species that produces each observation in the reaction of NaI with concentrated H_2SO_4.

black solid .....

yellow solid .....

effervescence .....

[2]

(d) Table 1.3 gives some information about $MgCl_2$ and $SiCl_4$.

Table 1.3

	$MgCl_2$	**$SiCl_4$**
electrical conductivity when liquid	conducts	does **not** conduct
observation when added to water	dissolves	vigorous reaction

(i) Explain the difference between the electrical conductivity of liquid $MgCl_2$ and of liquid $SiCl_4$. Refer to bonding and relevant particles in your answer.

.....

.....

.....

.....

..... [2]

(ii) Suggest the pH of the solutions that form when each chloride is added to water.

$MgCl_2$ ..... $SiCl_4$ .....

[2]

[Total: 22]

DO NOT WRITE IN THIS MARGIN DO NOT WRITE IN THIS MARGIN DO NOT WRITE IN THIS MARGIN DO NOT WRITE IN THIS MARGIN DO NOT WRITE IN THIS MARGIN

BLANK PAGE

DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN

2 Aluminium oxide, Al_2O_3, and phosphorus(V) oxide, P_4O_{10}, are both used as reagents and catalysts.

(a) The melting point of Al_2O_3 is 2072 °C. The melting point of P_4O_{10} is 340 °C.

Explain the difference in the melting points of these two compounds.

.....

.....

.....

..... [3]

(b) A 5.00 dm^3 sealed flask contains 0.400 mol of CO(g) and 0.800 mol of H_2(g) and an Al_2O_3 catalyst. The flask is heated to a temperature of 290 °C and allowed to reach equilibrium. Equation 1 shows the reaction.

equation 1 $\quad CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$

The equilibrium constant, K_c, of equation 1 is given.

$$K_c = \frac{[CH_3OH]}{[CO][H_2]^2}$$

(i) State the units of K_c.

..... [1]

(ii) The equilibrium mixture contains 0.280 mol of CH_3OH(g).

Calculate the value of K_c.

Give your answer to **three** significant figures.

value of K_c = ... [3]

(iii) State and explain the effect, if any, on the value of K_c when the overall pressure in the sealed flask is increased.

.....

..... [1]

DO NOT WRITE IN THIS MARGIN

(c) P_4O_{10} catalyses the reversible reaction of CO with H_2 to form CH_3OH.

equation 1 $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$

P_4O_{10} then acts as a dehydrating agent, causing CH_3OH to form CH_3OCH_3.

(i) Explain how the presence of a catalyst affects a chemical reaction.

.....

.....

..... [1]

(ii) Construct an equation for the dehydration reaction of CH_3OH to form CH_3OCH_3.

..... [1]

(iii) Write an equation to show the reaction of P_4O_{10} with an excess of water.

..... [1]

[Total: 11]

DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN

3 Propan-2-ol, $(CH_3)_2CHOH$, is sometimes added to fuel to help it burn.

Fig. 3.1 shows some reactions of propan-2-ol.

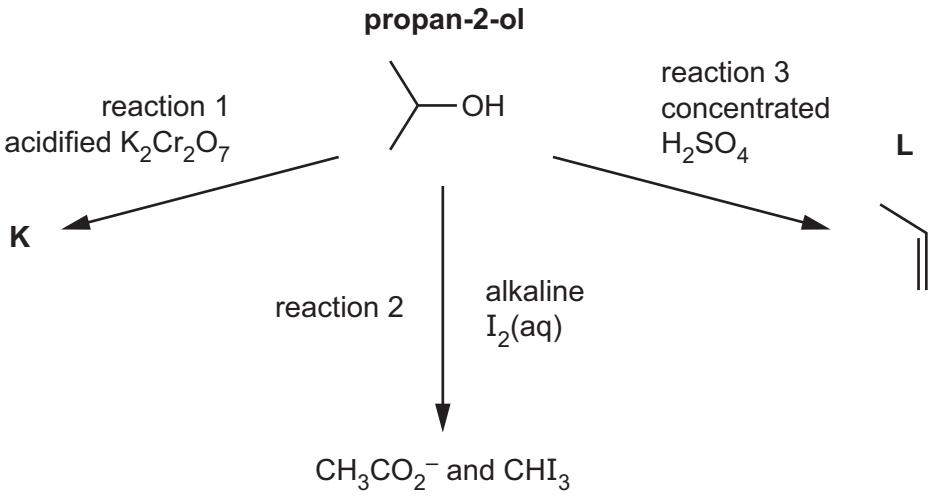


Fig. 3.1

(a) (i) Draw the structure of organic compound **K**.

[1]

(ii) State an observation you would make in reaction 2.

..... [1]

(iii) State the type of reaction that is shown in reaction 3.

..... [1]

(iv) Complete Fig. 3.2 to show the pi (π) bond in **L** that is formed from orbital overlap.

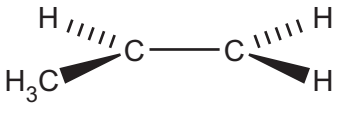


Fig. 3.2

[1]

DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN

(b) Propan-2-ol reacts with sodium to produce $(CH_3)_2CH–O^-$ anions.

These anions react with 2-bromopropane to form compound **N**, as shown in Fig. 3.3.

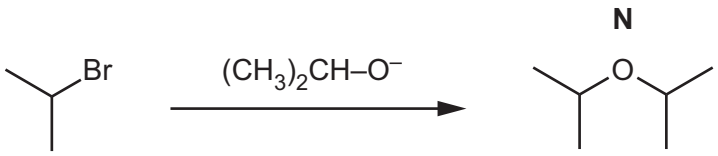


Fig. 3.3

(i) Write an equation for the reaction of propan-2-ol with sodium.

..... [1]

(ii) The reaction of 2-bromopropane with $(CH_3)_2CH–O^-$ anions follows an S_N1 mechanism.

Complete Fig. 3.4 to show this mechanism. Include charges, dipoles, lone pairs of electrons and curly arrows, as appropriate.



Fig. 3.4

[3]

(iii) Suggest how the rate of the S_N1 reaction would change, if at all, if 2-chloropropane were used instead of 2-bromopropane.

Explain your answer.

.....

.....

..... [2]

(iv) **N** is also added to petrol to make it burn more smoothly.

Construct an equation for the complete combustion of **N**, $C_6H_{14}O$.

$C_6H_{14}O$ ..... [1]

[Total: 11]

DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN

4 Compounds **P** and **Q** are structural isomers.

P **Q**



Fig. 4.1

(a) (i) Define structural isomerism.

.....

..... [2]

(ii) **P** shows geometrical isomerism.

Draw the geometrical isomer of **P**. Explain why the two isomers are **not** identical.

geometrical isomer of **P**

explanation .....

.....

.....

[2]

(iii) Both **P** and **Q** react with aqueous bromine.

Name the mechanism of this reaction.

..... [1]

(iv) **Q** is oxidised by hot concentrated acidified $KMnO_4(aq)$, forming two different organic products.

Construct an equation for this reaction. Use [O] to represent an atom of oxygen from the oxidising agent.

$(CH_3)_2C{=}CHCH_3$ ..... [2]

DO NOT WRITE IN THIS MARGIN DO NOT WRITE IN THIS MARGIN DO NOT WRITE IN THIS MARGIN DO NOT WRITE IN THIS MARGIN DO NOT WRITE IN THIS MARGIN

(v) **Q** reacts with HBr(g) to produce two structural isomers, **R** and **S**, as shown in Fig. 4.2.

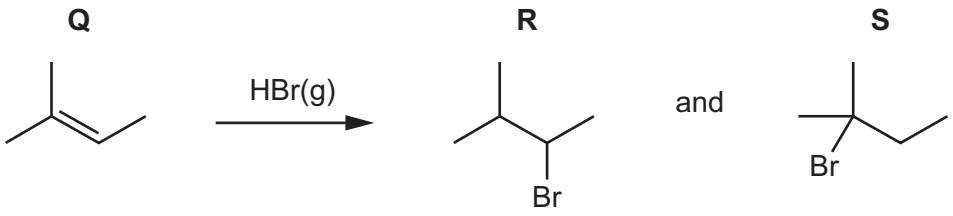


Fig. 4.2

State and explain why isomer **S** is the major product of the reaction.

.....

.....

..... [2]

(vi) The mass spectrum of **R** shows peaks at *m/e* = 150 and *m/e* = 152.

Suggest structures for the ions responsible for these peaks.

peak at *m/e* = 150	peak at *m/e* = 152

[2]

DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN

(b) Fig. 4.3 shows a synthesis starting from **T**, a different isomer of **R** and **S**.

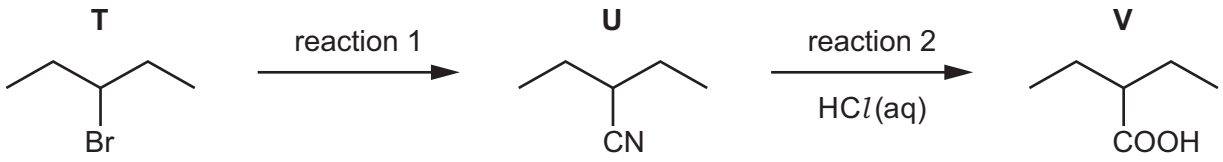


Fig. 4.3

(i) Identify the reagent and conditions for reaction 1.

..... [1]

(ii) Reaction 2 is a hydrolysis reaction.

Construct an equation for reaction 2.

$(C_2H_5)_2CHCN$ ..... [1]

(iii) **V** reacts with propan-2-ol in the presence of a catalytic amount of H_2SO_4 to form organic compound **W**.

Complete Table 4.1 to give details of this reaction.

Table 4.1

	reaction of **V** with propan-2-ol
type of reaction	
functional group formed	
molecular formula of organic product **W**	

[3]

[Total: 16]

DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN

BLANK PAGE

DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN



BLANK PAGE

DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN

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	$L = 6.02 \times 10^{23}\,\text{mol}^{-1}$
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	$c = 4.18\,\text{kJ kg}^{-1}\,\text{K}^{-1}$ ($4.18\,\text{J g}^{-1}\,\text{K}^{-1}$)

DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN
DO NOT WRITE IN THIS MARGIN

© UCLES 2025

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge Assessment International Education 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.

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 –

DO NOT WRITE IN THIS MARGIN DO NOT WRITE IN THIS MARGIN DO NOT WRITE IN THIS MARGIN DO NOT WRITE IN THIS MARGIN DO NOT WRITE IN THIS MARGIN