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CAMBRIDGE
International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

8135586161

CHEMISTRY **9701/22**

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.

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1 Oxygen reacts with many elements.

(a) (i) State the total number of electrons that occupy the 2p sub-shell in an oxygen atom.

..... [1]

(ii) Name the orbital that contains the highest energy electron in an oxygen atom. Draw the shape of this orbital.

name .....

shape

[1]

(b) Lithium reacts with oxygen to produce lithium oxide, Li_2O.

Li_2O is a white solid with a melting point over 1400 °C.

Draw a dot-and-cross diagram to show the arrangement of **all** the electrons in Li_2O.

[2]

(c) Li_2O reacts with water to produce a solution with pH greater than 10.

(i) State the name of a Period 3 oxide that behaves in the same way as Li_2O when added to water.

..... [1]

(ii) Construct an equation for the reaction of Li_2O with water.

..... [1]

(iii) Identify **all** the Period 3 chlorides that are solid at room temperature and that react with water to produce an acidic solution.

..... [2]

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(d) $LiNO_3$ decomposes on heating to produce Li_2O, O_2 and a brown gas.

Identify the brown gas.

..... [1]

(e) Ammonia is made in the Haber process.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92.4\,kJ\,mol^{-1}$$

A temperature of 400–450 °C is used in the Haber process.

(i) State **two** other conditions used in the Haber process.

1 .....

2 .....

[2]

(ii) Describe how the initial rate of the forward reaction changes, if at all, when a temperature greater than 450 °C is used. Explain your answer.

Assume all other variables remain constant.

change in initial rate .....

explanation .....

.....

.....

[3]

[Total: 14]

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2 **(a)** Protons, neutrons and electrons are released with the same velocity from a source. Figure 2.1 shows the movement of two of these types of particle when they travel between oppositely charged plates.

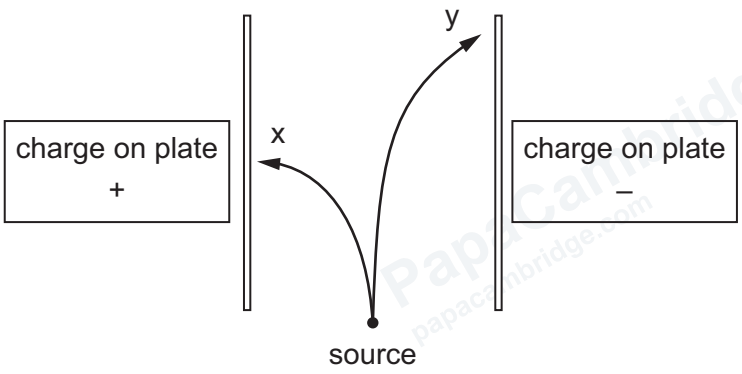

Figure 2.1

(i) Name each type of particle that produces the deflection shown by curves x and y.

curve x = ...

curve y = ...
[1]

(ii) Suggest why the particles producing curve y are deflected less than the particles producing curve x.

.....

..... [1]

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(b) A student considers the information in Table 2.1 and proposes hypothesis 1.

hypothesis 1 'Atoms with a higher nuclear charge are always larger.'

Table 2.1

atom	atomic number	mass number	atomic radius / nm
A	6	12	0.077
B	17	37	0.099
C	14	28	0.117

(i) Identify a pair of atoms from Table 2.1 that supports hypothesis 1.

..... [1]

(ii) Identify a pair of atoms from Table 2.1 that shows hypothesis 1 is false.

..... [1]

(iii) Explain why atom **A** is smaller than atom **C**.

.....

.....

.....

..... [2]

[Total: 6]

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3 Separate samples of NaCl and NaBr are reacted with concentrated H_2SO_4.
Table 3.1 shows the observations for each reaction.

Table 3.1

reaction	compound	observations
1	NaCl	• effervescence • steamy fumes that turn blue litmus paper red
2	NaBr	• effervescence • steamy fumes initially that turn blue litmus paper red • brown vapour • pungent smelling gas

(a) (i) Write an equation for reaction 1.

..... [1]

(ii) Explain why reaction 1 is described as a Brønsted–Lowry acid–base reaction.

.....

.....

..... [2]

(b) Identify the formula of each species responsible for the observations in reaction 2.

steamy fumes .....

brown vapour .....

pungent smelling gas .....

[3]

(c) Explain why reaction 2 produces brown vapour.

.....

..... [1]

(d) Explain why a gas with a pungent smell is **not** produced in reaction 1 but is produced in reaction 2.

.....

..... [1]

[Total: 8]

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4 **(a)** Figure 4.1 shows two reactions of compound **D**.

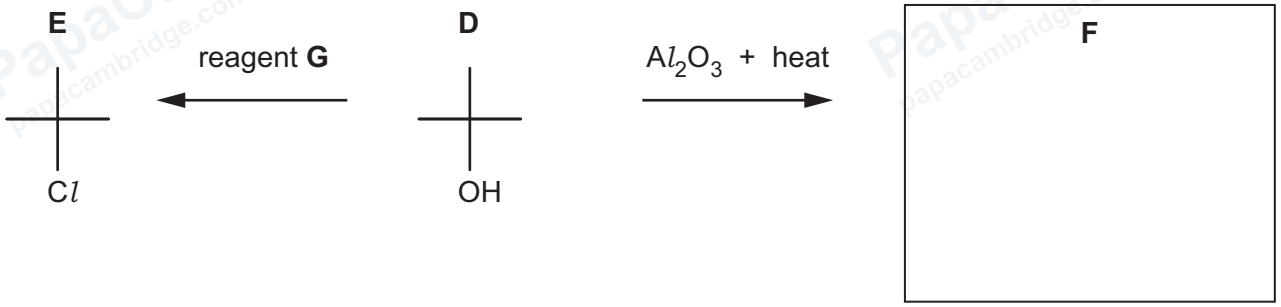

Figure 4.1

(i) **D** reacts with a single reagent, **G**, to produce compound **E**. Identify reagent **G**.

..... [1]

(ii) **D** is heated with Al_2O_3 to produce organic compound **F**.
Identify the role of Al_2O_3 in this reaction.

..... [1]

(iii) Draw the structure of **F** in Figure 4.1. [1]

(b) The structure of compound **X** is shown in Figure 4.2.

X

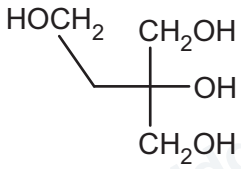

Figure 4.2

The molecular formula of **X** is $C_5H_{12}O_4$. Complete oxidation of 0.255 g of **X** occurs when it reacts with exactly 10.0 cm^3 of 0.500 mol dm^{-3} acidified $K_2Cr_2O_7$(aq).

(i) Describe the colour change in this reaction.

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

colour of mixture after the reaction .....

[1]

(ii) Calculate the amount, in mol, of $K_2Cr_2O_7$(aq) used in the reaction.

amount = ... mol [1]

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(iii) Calculate the amount, in mol, of **X** present in the 0.255 g sample.

amount = ... mol [1]

(c) (i) Compounds **X** and **W** are a pair of structural isomers.

0.0012 mol of **W** is completely oxidised when it is heated under reflux with exactly 0.0020 mol of acidified $K_2Cr_2O_7(aq)$ to produce compound **Z**.

Complete the equation for this reaction.

W **Z**

$$3C_5H_{12}O_4 + ...Cr_2O_7^{2-} + ...H^+ \rightarrow 3C_5H_6O_6 + ...Cr^{3+} + ...H_2O$$

[2]

(ii) Each molecule of **W** contains four hydroxyl groups. Only two of these are primary hydroxyl groups.

Table 4.1 shows the observations when separate samples of **Z** are added to each reagent.

Table 4.1

reagent	observations with Z
2,4-dinitrophenylhydrazine (2,4-DNPH)	orange precipitate
Fehling's reagent	none

Use the information in **4(c)** to suggest the structure of **W**.

W

[2]

[Total: 10]

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5 Hexane, $CH_3(CH_2)_4CH_3$, 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
$CH_3(CH_2)_5Cl$	
$CH_3(CH_2)_3CHClCH_3$	
$CH_3(CH_2)_3CHClCH_2Cl$	1,2-dichlorohexane
$CH_3(CH_2)_{10}CH_3$	dodecane
$CH_3(CH_2)_3CH(CH_3)CH(CH_3)(CH_2)_3CH_3$	5,6-dimethyldecane

(a) Complete Table 5.1. [2]

(b) The mechanism for the reaction of hexane with $Cl_2(g)$ involves three stages.

stage 1 initiation
stage 2 propagation
stage 3 termination

In stage 1 and 2, free radicals are produced.

(i) Describe what is meant by free radical.

.....

..... [1]

(ii) Name the type of bond breaking that occurs to produce the free radical •Cl from Cl_2.

..... [1]

(iii) Suggest a reaction sequence of **two** propagation reactions that result in $CH_3(CH_2)_4CH_3$ forming $CH_3(CH_2)_3CHClCH_3$.

propagation reaction 1

$CH_3(CH_2)_4CH_3$ ..... → .....

propagation reaction 2

..... → $CH_3(CH_2)_3CHClCH_3$ .....

[2]

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(iv) Suggest a reaction sequence of **one** propagation reaction followed by a termination reaction that results in $CH_3(CH_2)_4CH_3$ forming $CH_3(CH_2)_{10}CH_3$.

propagation reaction

$CH_3(CH_2)_4CH_3$ ..... → .....

termination reaction

..... → $CH_3(CH_2)_{10}CH_3$

[2]

(c) The proportion of each product varies depending on the type of free radical intermediate that is produced.

Table 5.2

primary free radical	**secondary free radical**	**tertiary free radical**
$•C(CH_3)H_2$	$•C(CH_3)_2H$	$•C(CH_3)_3$
→ increased stability of radical		

Use Table 5.2 to suggest which factor determines the increased stability of free radicals from primary to secondary to tertiary.

.....

..... [1]

[Total: 9]

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6 **(a)** Figure 6.1 shows the structure of compound **P**.

P

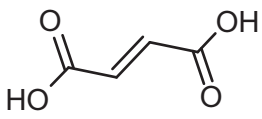

Figure 6.1

(i) Draw the structure of the stereoisomer of **P**.

[1]

(ii) Explain why **P** shows stereoisomerism.

.....

.....

..... [2]

(b) **P** reacts to produce compound **Q**.

P **Q**



Figure 6.2

(i) Identify the reagent and conditions required to convert **P** to **Q**.

reagent .....

conditions .....

[2]

(ii) Complete Figure 6.3 to show the pair of stereoisomers of **Q**.

isomer 1 isomer 2

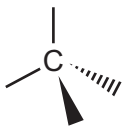

Figure 6.3

[2]

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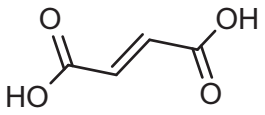
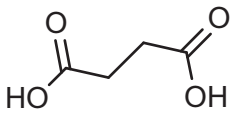
(c) An unlabelled sample contains one of compounds **P**, **R** or **S**.

P



R



S

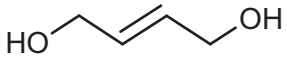


Figure 6.4

The mass spectrum of the sample is shown in Figure 6.5.

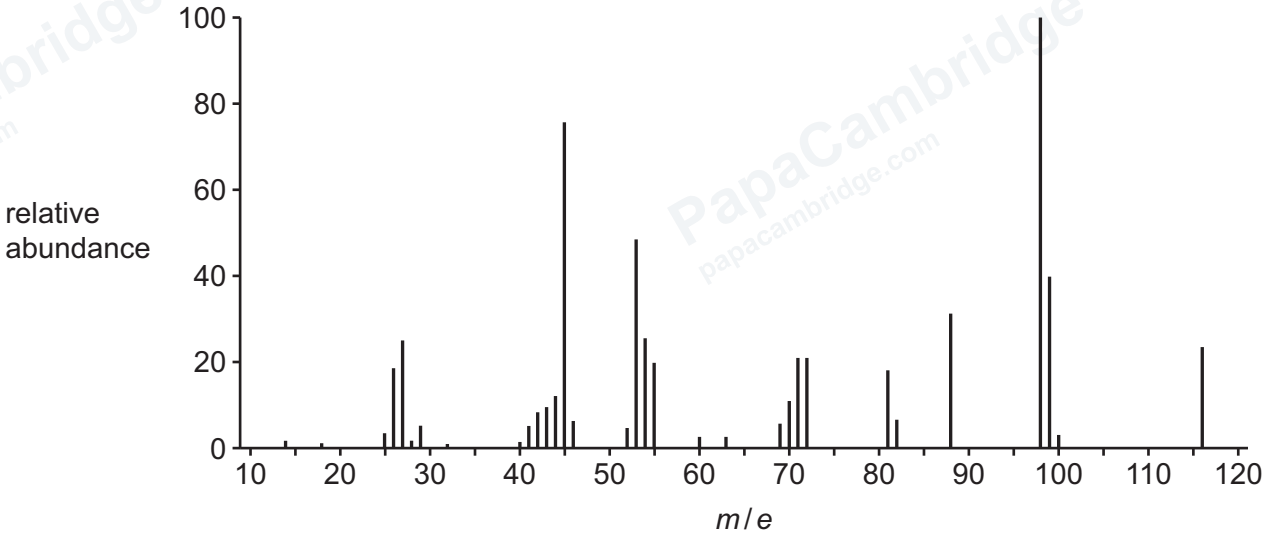


Figure 6.5

(i) Identify the **one** peak on Figure 6.5 which confirms that the sample is **P**.

Explain your reasoning.

.....

..... [2]

(ii) Suggest the structural formulae of the fragments responsible for the peaks at $m/e = 45$ and $m/e = 99$.

structural formula of fragment at $m/e = 45$ .....

structural formula of fragment at $m/e = 99$ .....

[2]

(iii) Suggest **one** reagent that is used to distinguish between samples of **R** and **S**. Include appropriate observations.

.....

.....

..... [2]

[Total: 13]

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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	$c = 4.18\,\text{kJ kg}^{-1}\,\text{K}^{-1}$ ($4.18\,\text{J g}^{-1}\,\text{K}^{-1}$)

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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 –

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