



Cambridge International AS & A Level

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CHEMISTRY

9701/21

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 (a) (i) Complete the dot-and-cross diagram in Figure 1.1 to show the arrangement of outer shell electrons in a molecule of SF_6 .

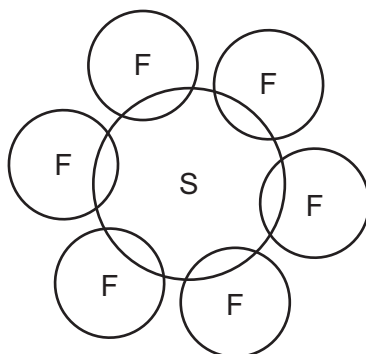


Figure 1.1

[1]

- (ii) Name the shape of a molecule of SF_6 .

[1]

- (b) Table 1.1 shows information about sulfur and chlorine.

Table 1.1

element	electronic configuration	first ionisation energy / kJ mol^{-1}
sulfur	$[\text{Ne}] 3s^2 3p^4$	1000
chlorine	$[\text{Ne}] 3s^2 3p^5$	1260

- (i) Name the orbital that contains the lowest energy electron in an atom of sulfur. Draw the shape of this orbital.

name

shape

[1]



- (ii) Construct an equation to represent the first ionisation energy of chlorine.

..... [1]

- (iii) Explain the difference in the values of first ionisation energy of sulfur and chlorine in Table 1.1.

.....

 [3]

- (c) A molecule of SCl_2 is polar.

- (i) Predict bond angle x in Figure 1.2 using VSEPR theory. Explain your answer.

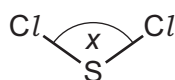


Figure 1.2

bond angle $x = \text{.....}^\circ$

explanation

 [3]

- (ii) Show on Figure 1.3 all the dipoles present in the molecule of SCl_2 .

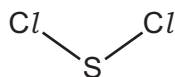


Figure 1.3

[1]

- (d) SCl_2 and H_2O both contain instantaneous dipole–induced dipole attractions and permanent dipole attractions.

- (i) Complete Table 1.2.

Table 1.2

	SCl_2	H_2O
total number of electrons per molecule		10

[1]

- (ii) Identify which molecule, SCl_2 or H_2O , has the stronger instantaneous dipole–induced dipole attractions. Explain your answer.

.....
 [1]

- (iii) H_2O has a greater dipole moment than SCl_2 . Explain why.

.....

 [1]

- (e) Compound **X** contains sulfur and chlorine only.

100.0 g of **X** contains 47.49 g of sulfur. The relative molecular mass, M_r , of **X** is 135.2.

Determine the molecular formula of **X**. Show your working.

molecular formula of **X** = [3]

[Total: 17]





Turn over

2 The Contact process uses sulfur to produce sulfuric acid.

stage 1 Sulfur is burned in excess air.

stage 2 $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g}) \quad \Delta H = -196 \text{ kJ mol}^{-1}$

stage 3 SO_3 reacts to produce H_2SO_4 .

(a) Write an overall equation for stage 3.

..... [1]

(b) The reaction conditions for stage 2 include:

- using a ratio of 1 mol SO_2 to 1 mol O_2
- heat in the presence of V_2O_5 .

(i) Stage 2 is repeated using a ratio of more than 1 mol SO_2 to 1 mol O_2 .

Predict the effect on the percentage yield of SO_3 at equilibrium. Use Le Chatelier's Principle to explain your answer.

.....

 [1]

(ii) Explain how V_2O_5 affects the rate of reaction.

.....

 [2]



- (c) CaCO_3 and O_2 are added to the waste gases from the Contact process before they escape. This prevents the release of SO_2 into the atmosphere.



- (i) State **one** environmental consequence of the release of $\text{SO}_2(\text{g})$ into the atmosphere.

..... [1]

- (ii) Use the ideal gas equation to calculate the volume of $\text{O}_2(\text{g})$ that reacts with 0.500 mol of SO_2 at 400°C and 101 kPa in equation 1.

Include units in your answer.

volume of $\text{O}_2(\text{g}) =$

units [4]

[Total: 9]

- 3 Separate samples of NaCl, NaBr and NaI each react with concentrated H₂SO₄. 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 smell of SO₂
3	NaI	- effervescence - steamy fumes initially that turn blue litmus paper red - purple vapour - pungent smell of SO₂ and then a rotten egg smell of H₂S

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

..... [1]

- (ii) Identify the reactant that behaves as a Brønsted–Lowry base in reaction 1.

..... [1]

- (b) State the formulae of the species responsible for the brown vapour in reaction 2 and for the purple vapour in reaction 3.

brown vapour

purple vapour [1]

- (c) Explain why reaction 3 produces purple vapour.

..... [1]



(d) Complete Table 3.2.

Table 3.2

species	oxidation number of sulfur
H ₂ SO ₄	
SO ₂	
H ₂ S	

[2]

(e) Explain why reaction 3 produces H₂S but reaction 2 does **not** produce H₂S.

.....
 [1]

(f) (i) Describe what is observed when Ag⁺(aq), followed by NH₃(aq), are added to a sample of NaI(aq).

observation after addition of Ag⁺(aq)

observation after addition of NH₃(aq) [2]

(ii) Write an ionic equation for the reaction of Ag⁺(aq) with NaI(aq).

..... [1]

[Total: 10]

- 4 (a) Compound **Z** is oxidised to produce organic compound **W**, $\text{C}_5\text{H}_6\text{O}_7$, by heating under reflux with an excess of acidified $\text{Cr}_2\text{O}_7^{2-}(\text{aq})$.

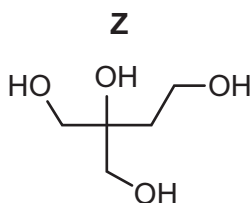


Figure 4.1

- (i) Describe the colour change in this reaction.

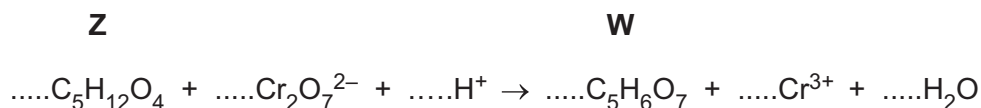
colour of mixture at start of the reaction

colour of mixture after the reaction

[1]

- (ii) The complete oxidation of 0.025 mol of **Z** requires 0.050 mol of $\text{Cr}_2\text{O}_7^{2-}(\text{aq})$. **W** is produced in this reaction.

Balance the equation for this reaction.



[1]

- (b) Compound **A** is a structural isomer of **Z**.

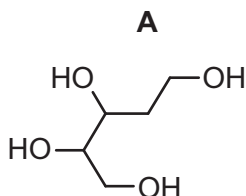


Figure 4.2

- (i) Complete Table 4.1 to show what is observed when separate samples of **A** are added to each reagent. State 'none' if no reaction occurs.

Table 4.1

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

[2]



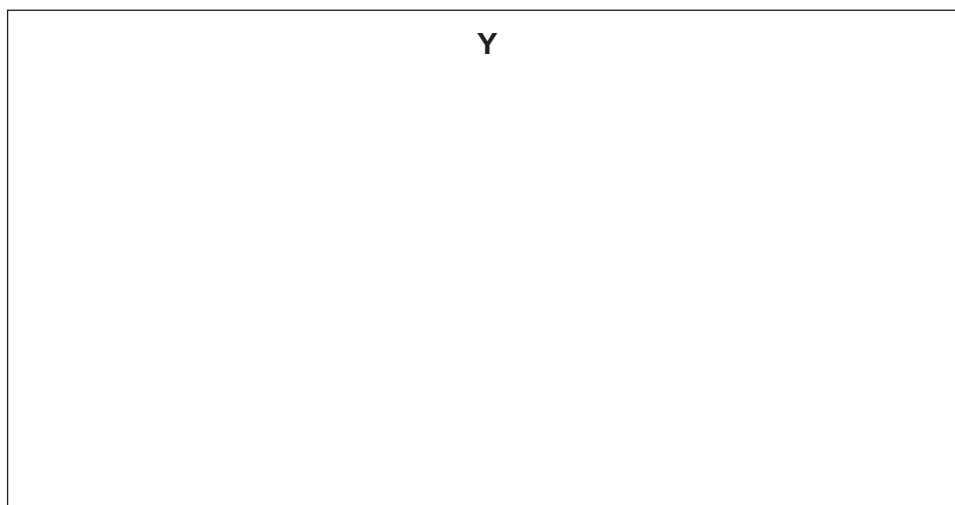
- (ii) Suggest why Fehling's reagent does **not** react with **A** but does react with aldehyde functional groups.

.....

 [1]

- (iii) Compound **A** is heated under reflux with an excess of acidified $\text{Cr}_2\text{O}_7^{2-}(\text{aq})$ to produce organic compound **Y**.

Draw the structure of **Y**.

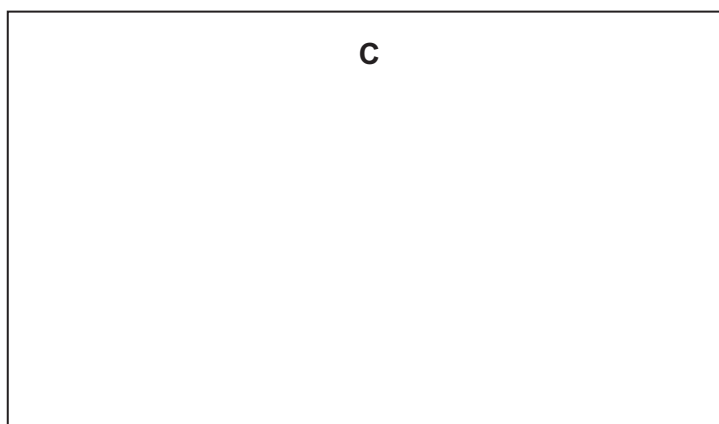
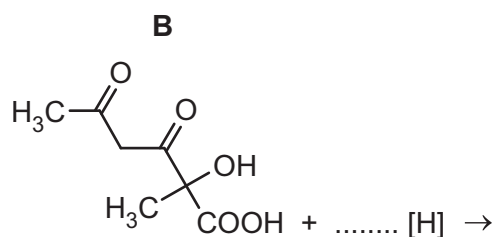


[2]

- (c) Compound **B** reacts with an excess of LiAlH_4 to produce organic compound **C**.

Complete the equation in Figure 4.3 to show the reaction of **B** with an excess of LiAlH_4 to produce **C**.

[H] represents one atom of hydrogen from the reducing agent, LiAlH_4 .



+

Figure 4.3

[2]

[Total: 9]

- 5 Figure 5.1 describes a sequence of reactions starting with ethene to produce poly(chloroethene), PVC.

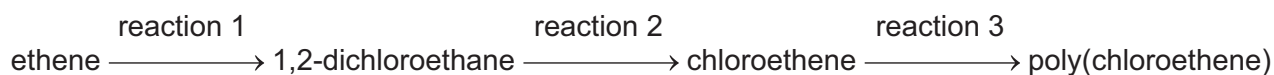


Figure 5.1

- (a) Complete Table 5.1.

Table 5.1

compound	type of hybridisation of carbon atoms
1,2-dichloroethane	
chloroethene	

[2]

- (b) In reaction 1, ethene reacts with $\text{Cl}_2(\text{g})$ at room temperature. Name the mechanism for reaction 1.

..... [1]

- (c) Describe what is meant by heterolytic fission of a covalent bond.

..... [2]

- (d) Complete Figure 5.2 to show the mechanism for the reaction of ethene with Cl_2 in reaction 1. Include charges, dipoles, lone pairs of electrons and curly arrows, as appropriate.



Figure 5.2

[4]



- (e) When 1,2-dichloroethane is heated in reaction 2, thermal decomposition occurs. The reaction is endothermic.

State the type of reaction that occurs.

..... [1]

- (f) Draw the repeat unit of poly(chloroethene).

[1]

- (g) Figure 5.3 shows the mass spectrum of chloroethene.

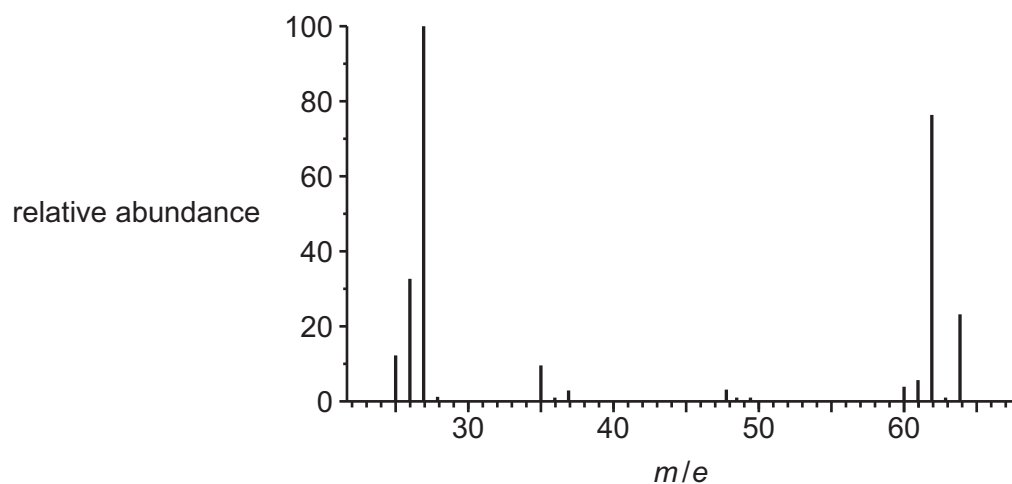


Figure 5.3

- (i) Identify the species responsible for the peaks at $m/e = 64$ and $m/e = 27$.

peak at $m/e = 64$

peak at $m/e = 27$

[2]

- (ii) Explain the difference in relative abundance of the peaks at $m/e = 62$ and $m/e = 64$.

.....

..... [2]

[Total: 15]





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	1 H hydrogen 1.0												13	14	15	16	17	18				
3 Li lithium 6.9		Key atomic number atomic symbol name relative atomic mass																2 He helium 4.0					
11	12																	5	6	7	8	9	10
Na sodium 23.0	Mg magnesium 24.3																	B boron 10.8	C carbon 12.0	N nitrogen 14.0	O oxygen 16.0	F fluorine 19.0	Ne neon 20.2
19	20																	13	14	15	16	17	18
K potassium 39.1	Ca calcium 40.1																	Al aluminium 27.0	Si silicon 28.1	P phosphorus 31.0	S sulfur 32.1	Cl chlorine 35.5	Ar argon 39.9
37	38																	31	32	33	34	35	36
Rb rubidium 85.5	Sr strontium 87.6																	Ga gallium 69.7	Ge germanium 72.6	As arsenic 74.9	Se selenium 79.0	Br bromine 79.9	Kr krypton 83.8
55	56																	49	50	51	52	53	54
Cs caesium 132.9	Ba barium 137.3																	In indium 114.8	Sn tin 118.7	Sb antimony 121.8	Te tellurium 127.6	I iodine 126.9	Xe xenon 131.3
87	88																	81	82	83	84	85	86
Fr francium —	Ra radium —																	Tl thallium 204.4	Pb lead 207.2	Bi bismuth 209.0	Po polonium —	At astatine —	Rn radon —
89–103 actinoids	89–103 actinoids																	112	114	115	116	117	118
																		Cn copernicium —	Fl flerovium —	Mc moscovium —	Lv livermorium —	Ts tennessine —	Og oganeson —

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