



Cambridge International AS & A Level

CANDIDATE
NAMECENTRE
NUMBER

--	--	--	--	--

CANDIDATE
NUMBER

--	--	--	--

CHEMISTRY

9701/53

Paper 5 Planning, Analysis and Evaluation

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 30.
- 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 **12** pages.

- 1 Solid mixture **X** contains **only** anhydrous calcium chloride, CaCl_2 , and anhydrous calcium nitrate, $\text{Ca}(\text{NO}_3)_2$. An experiment is done to find the percentage by mass of $\text{Ca}(\text{NO}_3)_2$ in the mixture.

step 1 Weigh an empty crucible. Add approximately 5 g of mixture **X** to the crucible.

step 2 Reweigh the crucible with mixture **X**.

step 3 Heat the crucible gently for one minute and then strongly for four minutes. The calcium nitrate decomposes.



step 4 Allow the crucible to cool. Reweigh the crucible and contents.

- (a) Identify the piece of apparatus that should be used to support the crucible during heating in step 3.

..... [1]

- (b) Suggest why heating is gentle at first in step 3.

..... [1]

- (c) Give **one** reason why the heating should be done in a fume hood.

..... [1]

- (d) The student carries out the experiment and obtains the results shown in Table 1.1.

Table 1.1

	mass / g
mass of crucible	12.74
mass of crucible + contents before heating	17.81
mass of crucible + contents after heating	16.53

- (i) Use the data from Table 1.1 to calculate the amount, in mol, of NO_2 gas lost during heating.

amount of NO_2 lost = mol [2]



- (ii) Calculate the percentage error in the measurement of the mass of the crucible + contents before heating.

Show your working.

percentage error = % [1]

- (iii) Other than changing the apparatus, suggest how the percentage error in **1(d)(ii)** can be reduced.

..... [1]

- (e) The experiment is repeated using 4.98 g of mixture **X**. In this experiment, 0.0223 mol of NO_2 gas is lost during heating.

Calculate the percentage by mass of $\text{Ca}(\text{NO}_3)_2$ in this sample of mixture **X**.

$[M_r: \text{Ca}(\text{NO}_3)_2, 164.1]$

percentage by mass of $\text{Ca}(\text{NO}_3)_2 = \dots\dots\dots\%$ [2]

- (f) (i) Suggest **one** additional step that should be done to ensure that the $\text{Ca}(\text{NO}_3)_2$ has completely thermally decomposed.

..... [1]

- (ii) State the effect on the percentage by mass of $\text{Ca}(\text{NO}_3)_2$ calculated in **1(e)** if the $\text{Ca}(\text{NO}_3)_2$ is **not** completely thermally decomposed. Explain your answer.

.....

..... [1]

- (g) A student wants to collect the NO_2 gas produced by the thermal decomposition of a sample of mixture **X** by cooling the gas mixture produced until the NO_2 condenses and the oxygen does **not**.

Table 1.2

	melting point/ $^{\circ}\text{C}$	boiling point/ $^{\circ}\text{C}$
nitrogen dioxide	-11	21
oxygen	-219	-183

Complete Figure 1.1 to show a labelled diagram of the laboratory apparatus that could be used to prepare liquid NO_2 from mixture **X**.

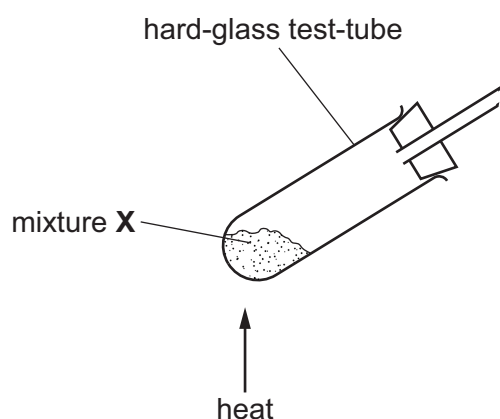


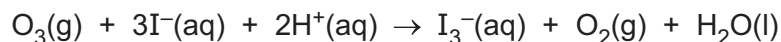
Figure 1.1

[2]

[Total: 13]

- 2 Ozone, $\text{O}_3(\text{g})$, is a pollutant at ground level. Some experiments are done to determine the concentration of $\text{O}_3(\text{g})$ in the air outside a school at different times of day.

The method involves bubbling a sample of air through a solution of acidified iodide ions, $\text{I}^-(\text{aq})$. Any $\text{O}_3(\text{g})$ in the sample of air reacts to form triiodide ions, $\text{I}_3^-(\text{aq})$.



When starch solution is added to the mixture, it forms a coloured complex with $\text{I}_3^-(\text{aq})$ ions. The concentration of $\text{I}_3^-(\text{aq})$ is found by colorimetry and the percentage of $\text{O}_3(\text{g})$ in the air is determined.

A diagram of the colorimeter used is shown in Figure 2.1.

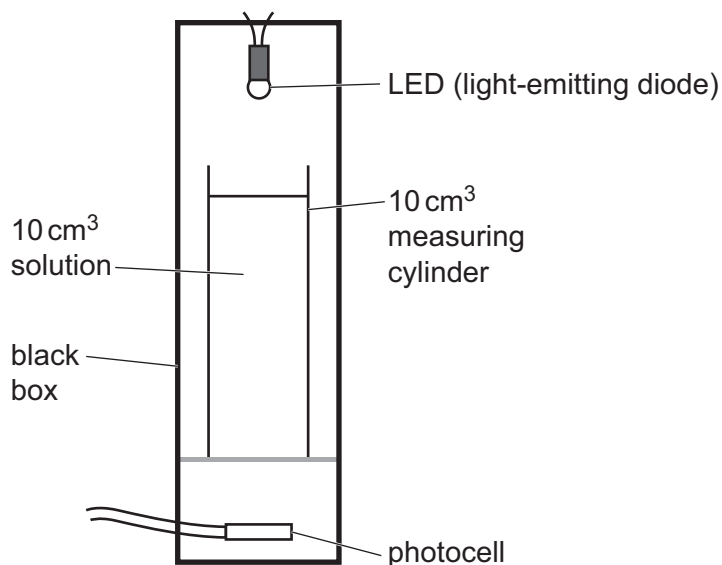


Figure 2.1

In the colorimeter, light from the LED passes through the solution in the measuring cylinder. Some of the light is absorbed by the complex containing starch and I_3^- ions. The photocell is used to determine the absorbance of the solution in the measuring cylinder.

- (a) Suggest **one** reason why the colorimeter must be enclosed in a black box.

.....
 [1]

- (b) To calibrate the colorimeter shown in Figure 2.1, five solutions of different known concentrations of $\text{I}_3^-(\text{aq})$ are prepared. For each solution, the following procedure is carried out.

- step 1** Place 15.0 cm^3 of $\text{I}_3^-(\text{aq})$ solution in a boiling tube.
- step 2** Add a few drops of starch solution to the boiling tube so that $\text{I}_3^-(\text{aq})$ ions form a coloured complex.
- step 3** Wait for ten minutes.
- step 4** Transfer 10.0 cm^3 of solution from the boiling tube to a 10 cm^3 measuring cylinder.
- step 5** Place the measuring cylinder into the colorimeter.
- step 6** Switch on the LED and record the resistance of the photocell.

The known concentrations of $\text{I}_3^-(\text{aq})$ used and the resistance readings of the photocell, R_s , are shown in Table 2.1.

The absorbance, A , of each solution is calculated using equation 1.

equation 1
$$A = \log (R_s / R_0)$$

R_0 is the resistance measured in a control experiment. The value of R_0 in this experiment is $4.85\text{ k}\Omega$.

Table 2.1

concentration of $\text{I}_3^-(\text{aq})$ / mol dm^{-3}	resistance of photocell, R_s / $\text{k}\Omega$	absorbance, A
3.60×10^{-6}	33.46	
2.94×10^{-6}	23.42	
2.20×10^{-6}	16.01	
1.52×10^{-6}	9.68	
7.90×10^{-7}	7.50	

- (i) Complete Table 2.1.
Record your values to **three** significant figures. [1]
- (ii) Suggest what was placed in the measuring cylinder in Figure 2.1 to obtain the value for R_0 . [1]
.....
- (iii) State the independent variable. [1]
.....
- (iv) Use the results from Table 2.1 to plot a graph on the grid in Figure 2.2 to show the relationship between absorbance, A , and the concentration of $\text{I}_3^-(\text{aq})$. Use a cross ($\times$) to plot each data point. Draw a line of best fit. [2]



absorbance,
 A

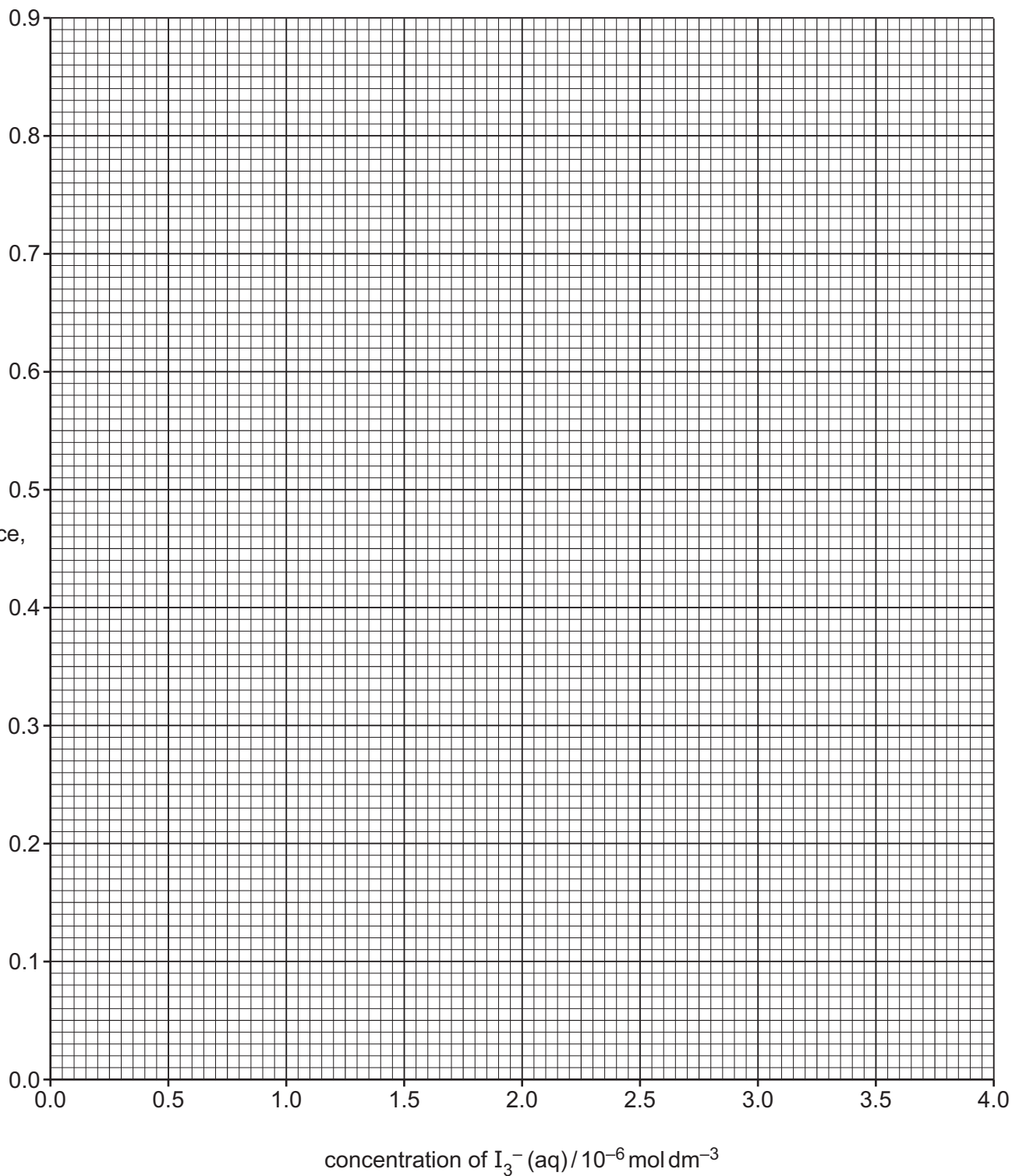


Figure 2.2

- (v) Circle the most anomalous point on the graph in Figure 2.2.
Suggest **one** reason to explain the anomalous point you have circled.
Assume no error was made in preparing the $I_3^-(aq)$ solution.

..... [1]

- (c) The following procedure is used to determine the concentration of $\text{O}_3(\text{g})$ in each sample of air.

step 1 Bubble air through a boiling tube containing 15.0 cm^3 of acidified aqueous iodide ions, $\text{I}^-(\text{aq})$, for 30 minutes, as shown in Figure 2.3.

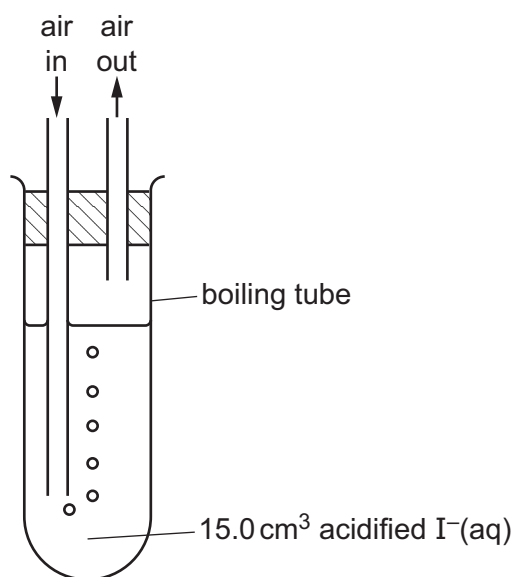


Figure 2.3

Repeat steps 2–6 from the procedure in **2(b)**.

- (i) Suggest a reason for waiting ten minutes after the starch solution is added (step 3).

..... [1]

- (ii) Identify the most appropriate piece of apparatus to transfer 10.0 cm^3 of the solution from the boiling tube to a 10 cm^3 measuring cylinder (step 4).

..... [1]



- (iii) A student follows the procedure and measures the photocell resistance, R_s , as 21.17 k Ω .

Use this information and your graph in Figure 2.2 to find the concentration, in mol dm⁻³, of I₃⁻(aq).

concentration of I₃⁻(aq) = mol dm⁻³ [2]

- (iv) Use your answer to **2(c)(iii)** to calculate the amount, in mol, of O₃(g) in the air bubbled through the boiling tube.

amount of O₃(g) = mol [1]

- (v) In step 1 in **2(c)**, the volume of air bubbled through the boiling tube in 30 minutes is 7500 cm³.

Use your answer to **2(c)(iv)** to calculate the concentration, in mol dm⁻³, of O₃(g) in the air.

[If you were unable to determine an answer to **2(c)(iv)**, then use amount of O₃(g) as 3.23 × 10⁻⁸ mol. This may **not** be the correct answer.]

concentration of O₃(g) = mol dm⁻³ [1]

- (vi) A student draws the line of best fit on the calibration graph that has a gradient which is too low.

State the effect, if any, on the calculated value for the concentration of $\text{O}_3(\text{g})$. Explain your answer.

.....
 [1]

- (vii) The procedure is repeated at different times of day. The resistances of the photocell are shown in Table 2.2.

Table 2.2

time of day	resistance of photocell, $R_s / \text{k}\Omega$
08:00	9.87
12:00	13.66

The total percentage error of each of the resistance readings is determined to be 14.0%. Use this value and the data from Table 2.2 to determine whether the difference in the readings at 08:00 and 12:00 can be accounted for by measurement error or whether there is a difference in the concentration of $\text{O}_3(\text{g})$ in the air.

Show your working.

..... [1]

- (viii) The procedure is repeated using a different type of 10 cm^3 measuring cylinder. The 10 cm^3 measuring cylinder used is narrower and taller than that used in the first experiment.

State the effect, if any, this would have on the value obtained for the resistance of the photocell, R_s . Explain your answer.

.....
 [1]

- (ix) The procedure is repeated but air is bubbled for more than 30 minutes in step 1.

Suggest **one** reason why it is better to bubble air through the solution for longer.

..... [1]

[Total: 17]



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	Key												13	14	15	16	17	18
		1Hhydrogen1.0																	
3Li lithium 6.9	4Be beryllium 9.0	atomic number atomic symbol name relative atomic mass												5B boron 10.8	6C carbon 12.0	7N nitrogen 14.0	8O oxygen 16.0	9F fluorine 19.0	10Ne neon 20.2
11Na sodium 23.0	12Mg magnesium 24.3													13Al aluminium 27.0	14Si silicon 28.1	15P phosphorus 31.0	16S sulfur 32.1	17Cl chlorine 35.5	18Ar argon 39.9
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	lanthanoids		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 —	actinoids		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 oganesson —		

lanthanoids

actinoids

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	euporium	152.0	64	Gd	gadolinium	157.3	65	Tb	terbium	158.9	66	Dy	dyprosium	162.5	67	Ho	holmium	164.9	68	Er	erbium	167.3	69	Tm	thulium	168.9	70	Yb	yterbium	173.1	71	Lu	lutetium	175.0
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	—

