

TEMASEK JUNIOR COLLEGE
2026 JC2 PRELIMINARY EXAMINATION
Higher 2



CANDIDATE
NAME

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CLASS

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CENTRE
NUMBER

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INDEX
NUMBER

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Chemistry

9476/04

Paper 4 Practical

27 August 2026

2 hours 30 minutes

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

Write your name, CG, centre number and index number on all the work you hand in.
Give details of the practical shift and laboratory where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.
Qualitative Analysis Notes are printed on pages 18 to 20.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [] at the end of each question or part question.

Shift
Laboratory

For Examiner's Use	
1	
2	
3	
4	
Total	

This document consists of **20** printed pages.

Answer **all** the questions in the spaces provided.

1 Qualitative analysis

At each stage of any test you are to record details of the following:

- colour changes seen
- the formation of any precipitate
- the solubility of such precipitates in an excess of the reagent added.

Test and identify any gases evolved.

You should indicate clearly at what stage in a test a change occurs.

No additional tests for ions present should be attempted.

Rinse and reuse test-tubes and boiling tubes where possible.

- (a) **FA 1** is a mixture of two salts, each of which contains a single cation and a single anion from those listed in the Qualitative Analysis Notes on pages 18 to 20.

Do the following tests and record your observations in Table 1.1 below.

Table 1.1

test	observations
(i) Place a small spatula of FA 1 in a test-tube. Carefully add dilute sulfuric acid until the reaction is complete.	
Then add aqueous sodium hydroxide with shaking, until the aqueous sodium hydroxide is in excess.	
(ii) To a 3 cm depth of deionised water in a boiling tube, add the remaining sample of FA 1. Stir and then filter the mixture into a clean boiling tube. You will use this solution for tests (iii) – (v).	

(iii) Add 1 cm depth of the solution from (ii) into a clean test-tube. Add aqueous sodium hydroxide slowly, until the aqueous sodium hydroxide is in excess.	
(iv) Add 1 cm depth of the solution from (ii) into a clean test-tube. Add aqueous ammonia slowly, until the aqueous ammonia is in excess.	
Then add a spatula full of ammonium chloride.	
(v) Add 1 cm depth of the solution from (ii) into a clean test-tube. Add 1 cm depth of aqueous barium nitrate. Add dilute nitric acid until the nitric acid is in excess.	

[4]

(vi) Complete Table 1.2 to identify the cations and anions present in **FA 1**.

Table 1.2

	FA 1
cations present	
anions present	

[2]

(vii) With the aid of an equation, explain your observation in part **(a)(i)** that allows you to identify one of the cations.

.....

[1]

(viii) Give one reason why it is necessary to perform (a)(ii) before (a)(iii) and (a)(iv).

.....

[1]

(b) Organic analysis

FA 2, FA 3 and FA 4 are aqueous solutions of organic compounds.

All **FA 2, FA 3 and FA 4** contain carbon, hydrogen and oxygen only and they each contain one type of functional group.

You will carry out tests to identify the functional groups present in **FA 2, FA 3 and FA 4** and to deduce the structures of **FA 2 and FA 4**.

- (i) Perform the tests described in Table 1.3. Some of the observations have been completed for you. There is no need to carry out these tests. Record your observations in Table 1.3.

Test and identify any gases evolved. If there is no observable change, write **no observable change**.

When organic solutions are to be heated, a hot water bath should be used.

Table 1.3

test		observations		
		FA 2	FA 3	FA 4
1	Add 1 cm depth of the FA solution in a test-tube. Add a small spatula of sodium carbonate to the test-tube.			
2	Add 1 cm depth of the FA solution in a test-tube. Add 5 cm depth of 2,4-dinitrophenylhydrazine solution to the test-tube.	no observable change	no observable change	orange precipitate observed
3	Add a few drops of the FA solution in a test-tube. Add a spatula of PCl_5 to the test-tube.	white fumes observed	white fumes observed	no observable change
4	Add 1 cm depth of the FA solution in a test-tube. Add 15 drops of dilute sulfuric acid followed by 1 drop of acidified potassium manganate(VII). Place the test-tube in the hot water bath and leave to stand.			

[2]

- (ii) Using your observations from Table 1.3, deduce the functional group present in both **FA 2** and **FA 3**.

.....
[1]

- (iii) Hence, suggest a possible structure of **FA 2** that is consistent with all the observations in Table 1.3. [1]

- (iv) The relative molecular mass of **FA 4** is determined to be 58.0.
Using your observations from Table 1.3, suggest the structure of **FA 4**.
Give evidence to support your conclusion.

[Ar: H, 1.0; C, 12.0; O, 16.0]

.....
.....
.....[1]

[Total: 13]

2 Investigate the kinetics of the reaction between M^{3+} ions and iodide ions

FA 5 is $0.0500 \text{ mol dm}^{-3}$ aqueous potassium iodide, KI.

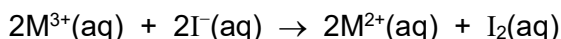
FA 6 is an acidified solution of $M^{3+}(\text{aq})$.

FA 7 is $0.00500 \text{ mol dm}^{-3}$ sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$.

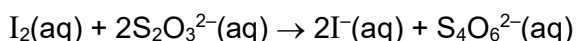
You are also provided with:

- starch solution
- deionised water

In acidic solutions, M^{3+} ions react with iodide ions according to the equation shown.



In this experiment, the rate of the reaction can be investigated by using starch indicator, which turns blue-black in the presence of iodine. Sodium thiosulfate is added to the reaction mixture to react with iodine as it is formed. When all the thiosulfate has reacted, the black-blue colour is observed.



You will perform a series of five experiments to investigate how the rate of reaction is affected by changing the concentration of the iodide ions. You will measure the time, t , for the blue-black colour to appear. For each experiment, you will need to ensure that the total volume of reaction mixture used is constant, by adding deionised water as required.

(a) Prepare a table in the space provided on page 8 in which to record, to an appropriate degree of precision:

- the volumes of **FA 5**, **FA 7** and deionised water used
- all values of t
- calculated values of rate.

Experiment 1

1. Use a 25 cm^3 measuring cylinder to place 20.0 cm^3 of **FA 5** in a 100 cm^3 beaker.
2. Use appropriate measuring cylinders to add the following to the same beaker.
 - 20.0 cm^3 of **FA 7**
 - 10.0 cm^3 of **starch**
3. Use an appropriate measuring cylinder to measure 10.0 cm^3 of **FA 6**.
4. Add this **FA 6** to the same 100 cm^3 beaker and start the stopwatch immediately.
5. Stir the mixture once and place the beaker on a white tile.
6. Stop timing as soon as the solution turns blue-black. Ignore any colour changes that occur before the intense blue-black colouration.
7. Record this reaction time to the nearest second.
8. Wash the beaker and dry it with a paper towel.

Experiment 2

1. Use a 25 cm³ measuring cylinder to measure 10.0 cm³ of **FA 5** in a 100 cm³ beaker.
2. Use appropriate measuring cylinders to add the following to the same beaker.
 - 10.0 cm³ of deionised water
 - 20.0 cm³ of **FA 7**
 - 10.0 cm³ of **starch**
3. Use an appropriate measuring cylinder to measure 10.0 cm³ of **FA 6**.
4. Add this **FA 6** to the same 100 cm³ beaker and start the stopwatch immediately.
5. Stir the mixture once and place the beaker on a white tile.
6. Stop timing as soon as the solution turns blue-black. Ignore any colour changes that occur before the intense blue-black colouration.
7. Record this reaction time to the nearest second.
8. Wash the beaker and dry it with a paper towel.

Experiments 3-5

Carry out three further experiments to investigate how the reaction time changes with different volumes of potassium iodide, **FA 5**. In each case, you will need to ensure that the total volume of the **FA 5** and deionised water is always 20.0 cm³. Do not use a volume of **FA 5** that is less than 6.0 cm³.

Results

The rate of the reaction can be calculated as shown.

$$\text{rate} = \frac{1000}{\text{reaction time}}$$

- (b) Explain why $\left(\frac{1000}{\text{time}}\right)$ is indicative of the rate of reaction.

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.....[1]

- (c) Plot a graph of rate, on the y-axis, against volume of **FA 5**, on the x-axis, on the grid in Fig. 2.1, and include the origin (0,0). Draw a line of best fit through the points.

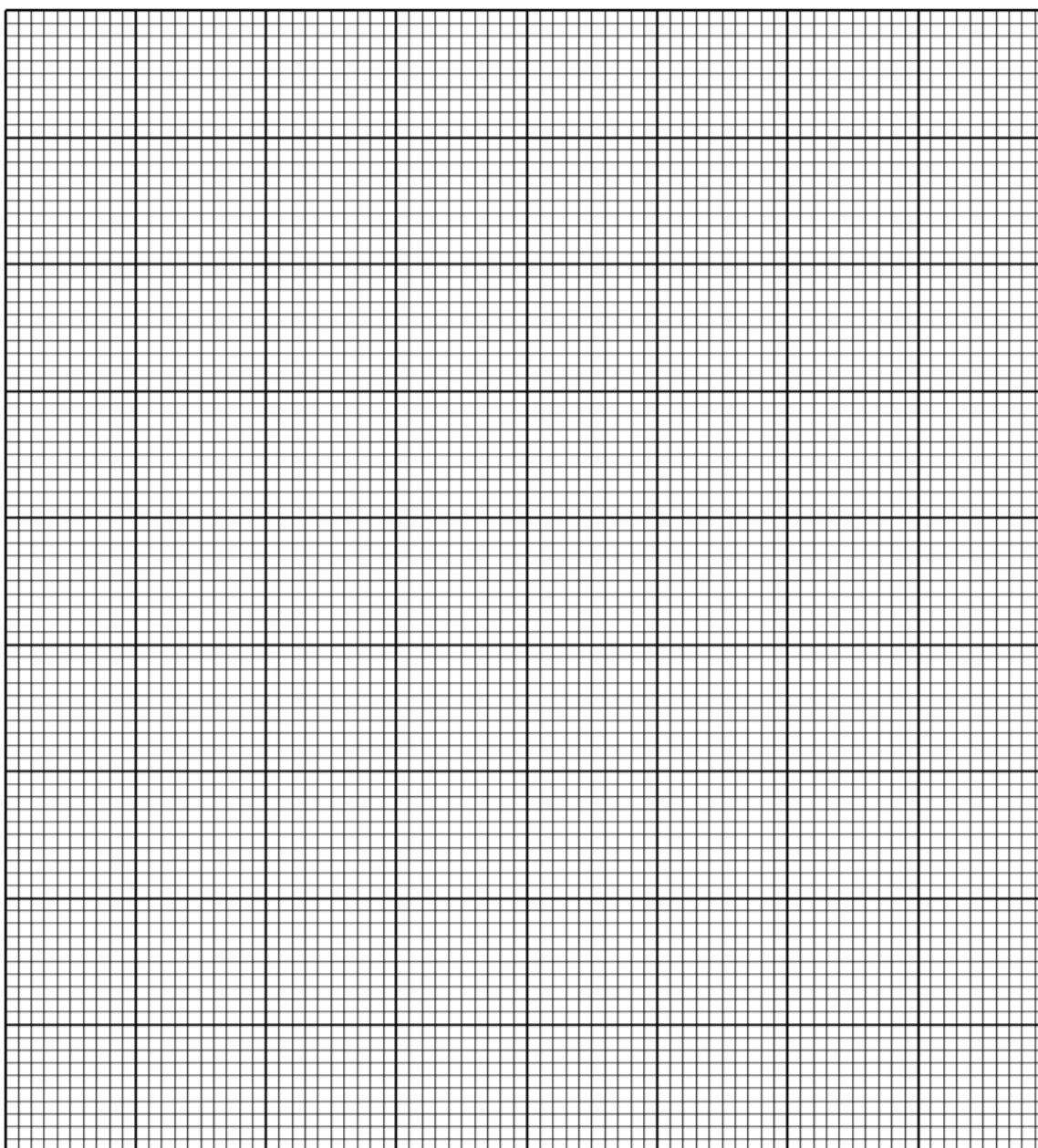


Fig. 2.1

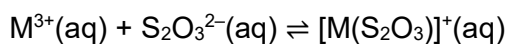
- (d) Use your graph to calculate the time that the reaction would have taken if 5.0 cm³ of **FA 5** had been used.

[1]

- (e) Using data from **Experiment 1 and 2**, show by calculation that the volume of aqueous potassium iodide, **FA 5**, used was directly proportional to the concentration of iodide ions.

[2]

- (f) M³⁺ ions reacts with thiosulfate to form a purple complex [M(S₂O₃)]⁺.



When **FA 6** was first added to the solution in step 4 of (a), the colourless mixture turns brown then yellow before turning blue-black.

Suggest an explanation for the colour changes from colourless to brown to yellow in terms of the chemistry involved.

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.....[2]

[Total: 14]

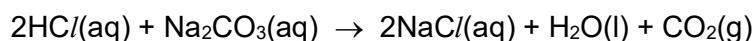
3 Determination of the percentage purity of a sample of sodium carbonate

In this question, you will determine the percentage purity of a sample of contaminated sodium carbonate.

A sample of contaminated sodium carbonate is dissolved in deionised water and diluted.

You will titrate the diluted solution of the contaminated sodium carbonate with hydrochloric acid of known concentration. You may assume that the impurities do not react with acid.

Sodium carbonate reacts with hydrochloric acid according to the equation shown.



FA 8 was prepared as follows:

- 45.8 g of the contaminated sodium carbonate sample was dissolved in deionised water and the solution was made up to 1 dm³.
- 28.00 cm³ of the solution was then made up to 250 cm³ with deionised water.

FA 9 is 0.100 mol dm⁻³ hydrochloric acid, HCl.

Solution I is methyl orange indicator.

(a) (i) Titration of FA 8 against FA 9

1. Fill the burette with **FA 9**.
2. Use the pipette to transfer 25.0 cm³ of **FA 8** into a 250 cm³ conical flask.
3. Add a few drops of **Solution I** to the same conical flask.
4. Titrate the mixture in the conical flask until the end-point is reached.
5. Record your titration results, to an appropriate level of precision, in the space provided below.
6. Repeat steps 2 to 5 until consistent results are obtained.

Titration results

[5]

- (ii) From your titrations, obtain a suitable volume of **FA 9** to be used in your calculations. Show clearly how you obtained this volume.

volume of **FA 9** = [1]

- (b) (i) Calculate the amount of sodium carbonate in 25.0 cm³ of **FA 8**.

amount of sodium carbonate = [1]

- (ii) Calculate the concentration, in mol dm⁻³, of sodium carbonate in the contaminated sample solution used to prepare **FA 8**.

concentration of sodium carbonate = mol dm⁻³ [2]

- (iii) Calculate the percentage purity by mass of the sodium carbonate in the contaminated sample.

[Ar: H, 1.0; C, 12.0; O, 16.0; Na, 23.0]

percentage purity by mass of sodium carbonate = [3]

- (c) A student suggested using $0.100 \text{ mol dm}^{-3}$ sulfuric acid in place of the $0.100 \text{ mol dm}^{-3}$ hydrochloric acid used in the experiment in (a)(i).

Explain what effect this change would have on the percentage error of the experiment.

FA 8 was prepared using the same procedure and quantities described on page 11.

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[1]

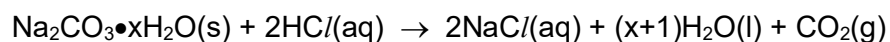
[Total: 13]

4 Planning

When sodium carbonate is crystallised from solution, it forms crystals of hydrated sodium carbonate, $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$.

- (a) The value of x in a sample of sodium carbonate crystals, $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$, is determined to be 10 via titration.

The value of x can also be determined by adding the sample to an **excess** of hydrochloric acid and measuring the volume of carbon dioxide gas formed.



- (i) Using $x = 10$, calculate the mass of sodium carbonate crystals required to form 75 cm^3 of carbon dioxide gas.

Assume that the percentage purity of the sample is 100 % and the molar volume of gas under experimental conditions is $24 \text{ dm}^3 \text{ mol}^{-1}$.

[A_r : H, 1.0; C, 12.0; O, 16.0; Na, 23.0]

[1]

- (ii) Hence, calculate the minimum volume of $0.100 \text{ mol dm}^{-3} \text{ HCl}(\text{aq})$ required for the experiment.

[1]

- (b) Using your answers in (a), plan an investigation to determine the value of x in the sample of sodium carbonate crystals by adding it to an excess of hydrochloric acid and measuring the volume of carbon dioxide gas formed using a gas syringe.

You may assume that you are provided with:

- the sample of sodium carbonate crystals, $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$, in (a)
- $0.100 \text{ mol dm}^{-3}$ hydrochloric acid, HCl
- 100 cm^3 gas syringe with glass tubing
- the equipment normally found in a school or college laboratory.

In your plan, you should include brief details of:

- the apparatus you would use
- the quantities you would use
- the procedure you would follow
- the measurements you would make
- how you would ensure that an accurate and reliable value of x is obtained.

Your plan should include a well-labelled diagram of the apparatus set-up.

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[5]

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- (c) Given that the amount of carbon dioxide gas collected is y mol and the mass of sodium carbonate crystals, $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}$, added is m g, show how you would calculate a value for x .

[1]

- (d) One of the errors associated with this method is caused by the loss of carbon dioxide gas. State the effect of this error, if any, on the value of x calculated. Explain your answer.

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.....[2]

[Total: 10]

Qualitative Analysis Notes

[ppt. = precipitate]

(a) Reactions of aqueous cations

cation	reaction with	
	NaOH(aq)	NH ₃ (aq)
aluminium, Al ³⁺ (aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH ₄ ⁺ (aq)	ammonia produced on heating	–
barium, Ba ²⁺ (aq)	no ppt. (if reagents are pure)	no ppt.
calcium, Ca ²⁺ (aq)	white ppt. with high [Ca ²⁺ (aq)]	no ppt.
chromium(III), Cr ³⁺ (aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess
copper(II), Cu ²⁺ (aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe ²⁺ (aq)	green ppt., turning brown on contact with air insoluble in excess	green ppt., turning brown on contact with air insoluble in excess
iron(III), Fe ³⁺ (aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
magnesium, Mg ²⁺ (aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn ²⁺ (aq)	off-white ppt., rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess
zinc, Zn ²⁺ (aq)	white ppt. soluble in excess	white ppt. soluble in excess

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(b) Reactions of aqueous anions

<i>anion</i>	<i>reaction</i>
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, $\text{Cl}^-(\text{aq})$	gives white ppt. with $\text{Ag}^+(\text{aq})$ (soluble in $\text{NH}_3(\text{aq})$)
bromide, $\text{Br}^-(\text{aq})$	gives pale cream ppt. with $\text{Ag}^+(\text{aq})$ (partially soluble in $\text{NH}_3(\text{aq})$)
iodide, $\text{I}^-(\text{aq})$	gives yellow ppt. with $\text{Ag}^+(\text{aq})$ (insoluble in $\text{NH}_3(\text{aq})$)
nitrate, $\text{NO}_3^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil
nitrite, $\text{NO}_2^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil; NO liberated by dilute acids (colourless $\text{NO} \rightarrow$ (pale) brown NO_2 in air)
sulfate, $\text{SO}_4^{2-}(\text{aq})$	gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (insoluble in excess dilute strong acids)
sulfite, $\text{SO}_3^{2-}(\text{aq})$	SO_2 liberated with dilute acids; gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (soluble in dilute strong acids)

(c) Test for gases

<i>gas</i>	<i>test and test result</i>
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	gives a white ppt. with limewater (ppt. dissolves with excess CO_2)
chlorine, Cl_2	bleaches damp litmus paper
hydrogen, H_2	"pops" with a lighted splint
oxygen, O_2	relights a glowing splint
sulfur dioxide, SO_2	turns aqueous acidified potassium manganate(VII) from purple to colourless

(d) Colour of halogens

<i>halogen</i>	<i>colour of element</i>	<i>colour in aqueous solution</i>	<i>colour in hexane</i>
chlorine, Cl_2	greenish yellow gas	pale yellow	pale yellow
bromine, Br_2	reddish brown gas / liquid	orange	orange-red
iodine, I_2	black solid / purple gas	brown	purple

(e) Test for organic compounds

<i>organic compound</i>	<i>reaction</i>
alkene	decolourises orange Br ₂ (aq)
chloroalkane	heat with NaOH(aq), white ppt. formed on adding dilute HNO ₃ , followed by Ag ⁺ (aq)
bromoalkane	heat with NaOH(aq), pale cream ppt. formed on adding dilute HNO ₃ , followed by Ag ⁺ (aq)
iodoalkane	heat with NaOH(aq), yellow ppt. formed on adding dilute HNO ₃ , followed by Ag ⁺ (aq)
alcohol	- forms white fumes with solid PCl₅ - decolourises purple acidified KMnO₄(aq) on heating (for primary and secondary alcohols) - gives pale yellow ppt. with alkaline I₂(aq) on warming (for alcohols with CH₃CH(OH)– group)
phenol	decolourises orange Br ₂ (aq) and forms a white ppt.
carbonyl compounds	- gives orange ppt. with 2,4-dinitrophenylhydrazine - gives pale yellow ppt. with alkaline I₂(aq) on warming (for carbonyl compounds with CH₃CO– group) - gives red-brown ppt. with Fehling's solution on warming (for aliphatic aldehydes) - gives silver mirror with Tollens' reagent on warming (for aldehydes)
carboxylic acid	- CO₂ liberated with Na₂CO₃(aq) - forms white fumes with solid PCl₅
phenylamine	decolourises orange Br ₂ (aq) and form a white ppt.
primary amide	NH ₃ liberated on heating with NaOH(aq)