



TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION

CANDIDATE NAME

CIVICS GROUP

H2 CHEMISTRY

9476/04

Paper 4 Practical

2 Sep 2026

2 hour 30 minute

Candidates answer on the Question Paper.

Additional Materials: As listed in the *Confidential Instructions*.

READ THESE INSTRUCTIONS FIRST

Write your name and Civics Group in the spaces at the top of the page.

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 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 19 - 21.

The number of marks is given in brackets [] at the end of each question or part question.

Shift
Laboratory

For Examiner's Use	
1	/ 11
2	/ 16
3	/ 13
4	/ 10
Total	/ 50

This document consists of **20** printed pages and **2** blank pages.



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

1 Investigation of some inorganic and organic reactions

In this question, you will be investigating some inorganic and organic reactions by carrying out the stipulated tests. Carefully record your observations in **Tables 1.1** and **1.2**.

Unless otherwise stated, the volumes given below are approximate and should be estimated rather than measured.

(a) Organic analysis

In this question, you will deduce the structure of an organic compound, **FA 1**.

FA 1 has the molecular formula $C_4H_8O_2$ with **two** functional groups present.

Do not carry out the tests for which observations have been recorded.

Do not use the Bunsen burner for heating in this part of the question. Instead, use the hot water provided.

Table 1.1

	tests	observations
(i)	Place about 2 cm depth of aqueous sulfuric acid in a test-tube. To this test-tube, add about 1 cm depth of FA 1 , followed by 1 drop of aqueous potassium manganate(VII). Warm the mixture in a hot water bath for two minutes.	
(ii)	Place about 1 cm depth of FA 1 in a test-tube. To this test-tube, add 2,4-dinitrophenylhydrazine dropwise.	Orange ppt. formed
(iii)	Add 1 cm depth of aqueous silver nitrate to a test-tube. Then slowly add 1 cm depth of aqueous sodium hydroxide. Add aqueous ammonia slowly, with shaking, until the precipitate just dissolves. To this mixture, add about 1 cm depth of FA 1 . Place the test-tube containing the mixture in a hot water bath for two minutes.	
(iv)	Place about 1 cm depth of FA 1 and add 8 drops of aqueous sodium hydroxide in a test-tube. Now, add iodine solution dropwise, until a permanent yellow / orange colour is obtained. Warm the mixture in a hot water bath for two minutes.	
(v)	Place 1 cm depth of FA 1 in a test-tube. To this test-tube, cautiously add a small piece of anhydrous phosphorus pentachloride.	Dense white fumes, which turns moist blue litmus paper red.

[2]



(b) **FA 1** has the molecular formula $C_4H_8O_2$ with **two** functional groups present.

- (i) Observations from **(a)(ii)** together with **(a)(iii)**, can be used to identify one of the functional groups present in **FA 1**.

Identify the functional group and explain your answer, showing clearly your reasoning.

Functional group:

Explanation:

.....

.....

[1]

- (ii) Observations from **either (a)(iv) or (a)(v)**, can be used to identify the other functional group present in **FA 1**.

Identify the functional group and explain your answer, showing clearly your reasoning.

Functional group:

Explanation:

.....

[1]

- (iii) Suggest a possible structure of **FA 1** that is consistent with all the observations in **Table 1.1**.

[1]

M1	M2	M3	M4	M5



(c) Inorganic analysis

FA 2 contains two cations and one anion listed in the Qualitative Analysis Notes on pages 19 – 20.

You should indicate clearly at what stage in a test a change occurs. Test and identify any gases evolved. If there is no observable change, write **no observable change**.

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

No additional tests should be attempted.

Table 1.2

	tests	observations
(i)	Test the FA 2 solution using Universal Indicator paper.	
(ii)	Add 2 cm depth of FA 2 into a test-tube. Add aqueous sodium hydroxide, slowly with shaking, until no further change is seen. Filter the mixture into a clean test-tube. To 1 cm depth of the filtrate, add dilute nitric acid dropwise until in excess.	
(iii)	Add 2 cm depth of FA 2 into a test-tube. Add aqueous ammonia, slowly with shaking, until no further change is seen. Filter the mixture into a clean test-tube. To 1 cm depth of the filtrate, add dilute nitric acid dropwise until in excess.	

	tests	observations
(iv)	Add 1 cm depth of FA 2 solution into a test-tube. Add a 1 cm depth of aqueous silver nitrate.	

[4]

(d) Use your observations in **Table 1.2** to identify the two cations and the anion in **FA 2**.

	identity
cation in FA 2	
cation in FA 2	
anion in FA 2	

[2]

M6	M7	M8	M9	M10	M11

[Total: 11]



2 Investigating the kinetics of the reaction between iodate(V) ions and hydrogensulfite ions

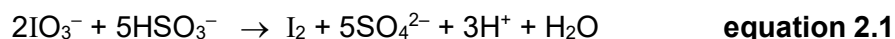
FA 3 is $0.100 \text{ mol dm}^{-3}$ potassium iodate(V), KIO_3

FA 4 is $0.0500 \text{ mol dm}^{-3}$ sodium hydrogen sulfite, NaHSO_3

You are also provided with:

- Solution **S**, 1% starch solution
- deionised water
- a waste container containing sodium carbonate solution

Iodate(V) ions react with hydrogensulfite ions according to the equation shown.



In this experiment, the rate of the reaction is studied by measuring the rate of formation of iodine using a 'clock' method. You will vary the concentration of iodate(V) ions and measure the time taken for a fixed amount of iodine to be produced. This will be indicated by the formation of a blue-black colour in the presence of starch.

The reaction takes place in a series of steps. As a result, the blue-black colour does not appear immediately.

You will perform a series of **five** experiments. For each experiment you will need to ensure that the same total volume of reaction mixture is used, by adding deionised water as required. For each experiment, you will measure the time, t , for the blue-black colour to appear. You should avoid inhaling any gases produced.

- (a) Prepare a table in the space provided on page 7 in which to record, to an appropriate degree of precision:
- the volumes of **FA 3** ($V_{\text{FA 3}}$), **FA 4** ($V_{\text{FA 4}}$) and deionised water (V_{water}) used
 - all values of t
 - calculated values of $\log(1/t)$
 - calculated values of $\log(V_{\text{FA 3}})$

Experiment 1

1. Use a teat pipette, add 0.5 cm^3 of Solution **S** to a 100 cm^3 conical flask.
2. Use a 10 cm^3 measuring cylinder to measure 3.0 cm^3 of **FA 3** into the conical flask.
3. Use a 25 cm^3 measuring cylinder to measure 15.0 cm^3 of deionised water into the same conical flask.
4. Use a second 10 cm^3 measuring cylinder to measure 2.0 cm^3 of **FA 4**.
5. Pour the **FA 4** into the same conical flask, starting the stopwatch during this addition.
6. Mix the contents thoroughly by swirling the flask several times. Place the flask on a white tile.
7. Stop the stopwatch at the first appearance of a blue-black colour.
8. Record the time taken, t , to the nearest second, in your table.
9. Discard the reaction mixture immediately into the waste container containing sodium carbonate solution.
10. Wash out the flask thoroughly with tap water and then with deionised water. Stand the flask upside down on a paper towel to drain.

Experiments 2 to 5

Repeat experiment 1 four times, adding 4.0 cm^3 , 6.0 cm^3 , 8.0 cm^3 and 10.0 cm^3 of **FA 3** respectively in step 2.

In each experiment, you should adjust the volume of deionised water in step 3 to ensure the **same total volume** of reaction mixture is used.

You should alternate the use of the two 100 cm^3 conical flasks.

Record all volumes, the time taken and the calculated values of $\log(1/t)$ and $\log(V_{\text{FA 3}})$ in your table.

Results

[4]

M12	M13	M14	M15

[Turn over]

- (b) (i) Plot a graph of $\log(1/t)$ on the y-axis against $\log(V_{\text{FA } 3})$ on the x-axis on the grid in Fig. 2.1. Draw the best-fit straight line.

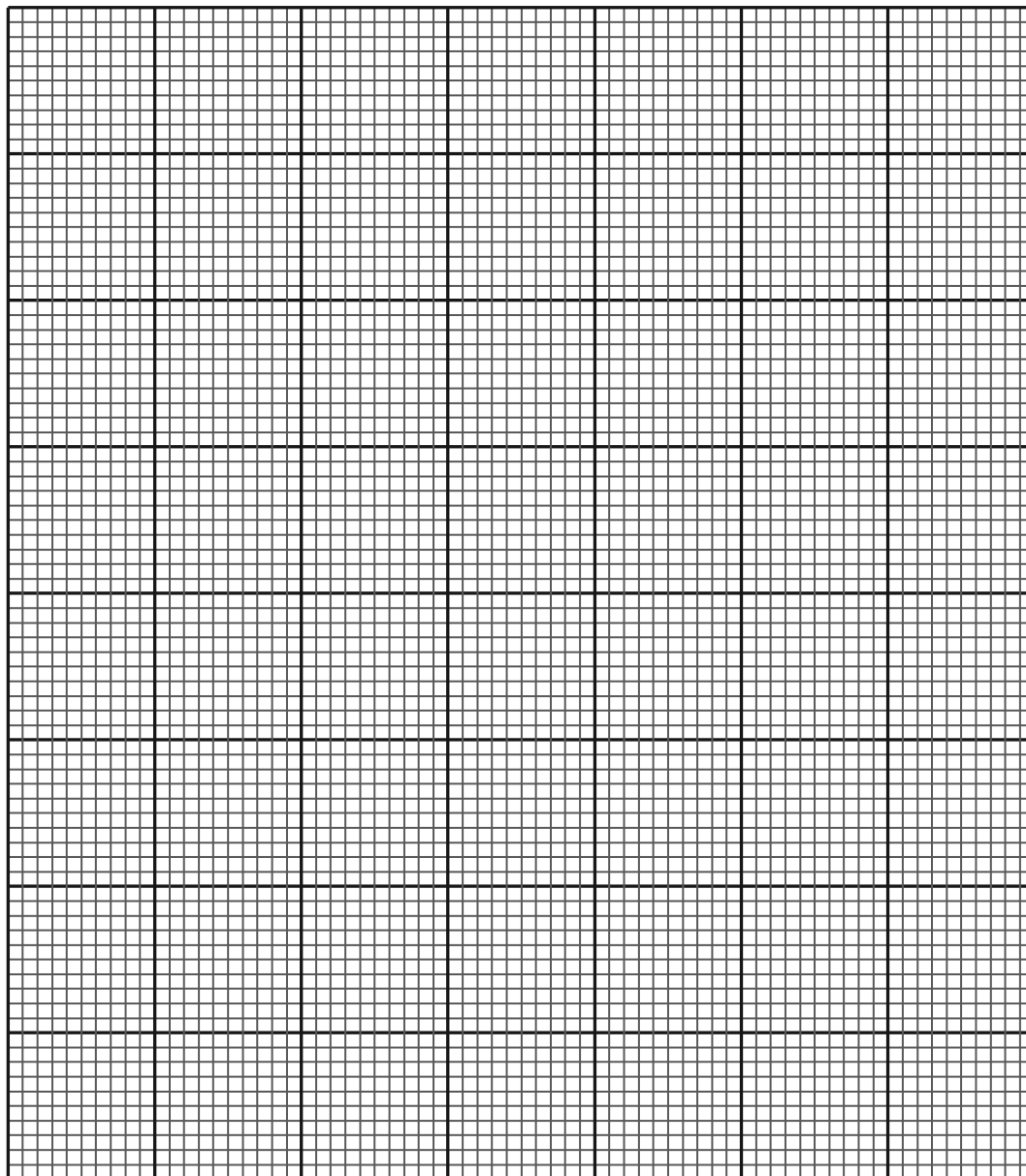


Fig. 2.1

[3]

- (ii) Explain why the volume of **FA 3** used in each experiment can be considered as a measure of $[\text{IO}_3^-]$.

.....
 [1]

M16	M17	M18	M19

- (iii) Calculate the gradient of the line to three significant figures, showing clearly how you did this. Hence, state the order of the reaction with respect to $[\text{IO}_3^-]$.

gradient =

order =

[2]

- (c) Step 10 of **Experiment 1** in 2(a) instructs you to wash **and** drain the conical flask before it is used again.

State and explain the likely effect on time taken, t , if a student had washed the conical flask but had failed to drain it before starting another experiment.

effect on t :

explanation:

.....
 [1]

M20	M21	M22



- (d) The average rate of decrease in iodate(V) ions, IO_3^- , up to the appearance of the blue-black colour can be estimated using:

$$\text{rate} = \left| \frac{\Delta[\text{IO}_3^-]}{\Delta t} \right|$$

For the purpose of this calculation, assume that the blue-black colour first appears when the hydrogensulfite ions initially present have just been consumed. **Equation 2.1** represents the overall reaction between iodate(V) ions and hydrogensulfite ions up to this point.

- (i) Calculate the amount of hydrogensulfite ions, HSO_3^- , initially present in each experiment. Hence, using **equation 2.1**, calculate the amount of iodate(V) ions, IO_3^- , consumed by the time the blue-black colour first appears.

amount of HSO_3^- ions initially present [1]

amount of IO_3^- ions consumed [1]

- (ii) Hence, calculate the average rate of decrease in $[\text{IO}_3^-]$ for **Experiment 1** in **2(a)**.

rate of decrease in $\text{IO}_3^- = \dots\dots\dots \text{mol dm}^{-3} \text{ s}^{-1}$ [1]

M23	M24	M25



- (e) Another student conducted the experiment. However, one of the student's plotted points lies significantly **above** the best-fit line drawn through the other points. Assume that the point was plotted correctly.

Suggest one experimental error that could have caused this anomaly. Explain your answer with reference to t , $1/t$ and $\log(1/t)$.

.....

.....

.....

.....

..... [2]

M26	M27

[Total: 16]



3 Standardisation of sodium hydroxide

Sodium hydroxide pellets cannot be obtained pure as they absorb moisture and carbon dioxide from the air. Hence, sodium hydroxide solutions are always standardised before use to determine their exact concentration.

Potassium hydrogen phthalate, $\text{KHC}_8\text{H}_4\text{O}_4$, is an organic acid of high purity that is used to standardise sodium hydroxide solutions. The M_r of $\text{KHC}_8\text{H}_4\text{O}_4$ is 204.2.

FA 5 is an aqueous solution of 8.15 g dm^{-3} $\text{KHC}_8\text{H}_4\text{O}_4$.

FA 6 is aqueous sodium hydroxide, NaOH .

You are to dilute a sample of **FA 6** and titrate **FA 5** with this diluted solution to find the concentration of NaOH in **FA 6**.

Solution **T** is thymolphthalein.

(a) Dilution of **FA 6**

1. Using a pipette, transfer 10.0 cm^3 of **FA 6** into a 250 cm^3 volumetric flask.
2. Make the solution up to the mark with deionised water and shake well to mix. Label this solution **FA 7**.

Titration of **FA 5** against **FA 7**

3. Fill a clean burette with **FA 7**.
4. Use a pipette to transfer 25.0 cm^3 of **FA 5** into a 250 cm^3 conical flask.
5. Add a few drops of solution **T** into the conical flask. Replace the cap on the container of solution **T** after use.
6. Titrate the solution in the conical flask with **FA 7**. The end-point is reached when the solution changes from colourless to a permanent **pale** blue colour.
7. Record your titration results, to an appropriate level of precision, in the space provided on page 13.
8. Repeat steps 4 to 7 until consistent results are obtained.



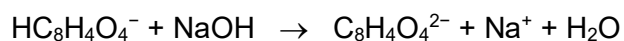
(i) Titration results

[5]

- (ii) From your titrations, obtain a suitable volume of **FA 7** to be used in your calculations. Show clearly how you obtain this volume.

volume of **FA 7** = [1]

- (b) The equation for the reaction in the titration is shown.



- (i) Calculate the concentration of NaOH in **FA 7**.

concentration of NaOH in **FA 7** = [2]

M28	M29	M30	M31	M32	M33	M34	M35

[Turn over]



- (ii) Hence, calculate the concentration of NaOH in **FA 6**.

concentration of NaOH in **FA 6** = [4]

- (c) A student used 25.0 cm³ of **FA 5** and obtained a **FA 7** titre value of 20.15 cm³ for the end point.

The errors (uncertainties) associated with each apparatus are given below.

pipette	$\pm 0.06 \text{ cm}^3$
burette	$\pm 0.05 \text{ cm}^3$

Use the above data to calculate the maximum total percentage error (uncertainty) in the volumes used to determine the concentration of **FA 7**.

maximum total percentage error [1]

M36	M37	M38	M39	M40

[Total: 13]



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[5]

M41	M42	M43	M44	M45



- (b) Sketch the graph that you would expect to obtain on the axes in Fig. 4.1. Explain how the maximum temperature change, ΔT_{max} , and the corresponding volume of H_2SO_4 , V_{neut} , can be determined. You may find it useful to show how this might be done on your graph.

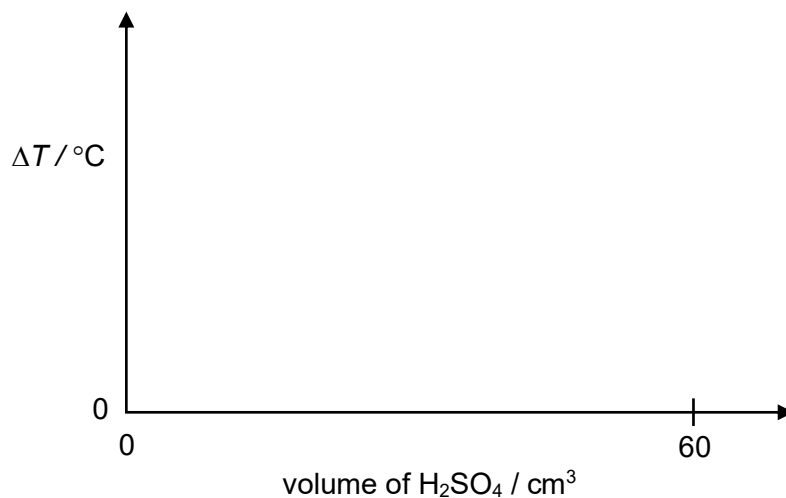


Fig. 4.1

.....

 [2]

- (c) Derive an expression for the concentration of NaOH in **FA 6**, in terms of V_{neut} only.

.....

 [2]

- (d) In **Question 3**, the equivalence volume, V_{eq} , determined by volumetric titration was used to calculate the concentration of NaOH in **FA 6**. Suggest why the method in **Question 3** gives a more accurate determination of the concentration of NaOH.

.....

 [1]

M46	M47	M48	M49	M50

[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



(b) Reactions of anions

<i>ion</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 excess dilute strong acids)

(c) Tests 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) Tests for organic compounds

<i>organic compounds</i>	<i>reactions</i>
alkene	decolourises orange $\text{Br}_2(\text{aq})$
chloroalkane	heat with $\text{NaOH}(\text{aq})$, white ppt. formed on adding dilute HNO_3 , followed by $\text{Ag}^+(\text{aq})$
bromoalkane	heat with $\text{NaOH}(\text{aq})$, pale cream ppt. formed on adding dilute HNO_3 , followed by $\text{Ag}^+(\text{aq})$
iodoalkane	heat with $\text{NaOH}(\text{aq})$, yellow ppt. formed on adding dilute HNO_3 , followed by $\text{Ag}^+(\text{aq})$
alcohol	- forms white fumes with solid PCl_5 - decolourises purple acidified $\text{KMnO}_4(\text{aq})$ on heating (for primary and secondary alcohols) - gives pale yellow ppt. with alkaline $\text{I}_2(\text{aq})$ on warming (for alcohols with $\text{CH}_3\text{CH}(\text{OH})-$ group)
phenol	decolourises orange $\text{Br}_2(\text{aq})$ and forms a white ppt
carbonyl compounds (aldehydes and ketones)	- gives orange ppt. with 2,4-dinitrophenylhydrazine - gives pale yellow ppt. with alkaline $\text{I}_2(\text{aq})$ on warming (for carbonyl compounds with $\text{CH}_3\text{CO}-$ 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	CO_2 liberated with $\text{Na}_2\text{CO}_3(\text{aq})$ - gives white fumes with solid PCl_5
phenylamine	decolourises orange $\text{Br}_2(\text{aq})$ and forms a white ppt
primary amide	NH_3 liberated on heating with $\text{NaOH}(\text{aq})$

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