



NATIONAL JUNIOR COLLEGE
SH 2 Prelim Practical Examination
Higher 2

CANDIDATE
NAME

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SUBJECT
CLASS

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REGISTRATION
NUMBER

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CHEMISTRY

9476/04

Paper 4 Practical

Monday 31 August 2026

You must answer on the question paper.

2 hours 30 minutes

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your identification number and name.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen. Do **not** use correction fluid or tape.
- You may use an approved calculator.
- Qualitative analysis notes are printed in the question paper.
- Write the details of the shift and laboratory in the boxes provided.

INFORMATION

- The total mark for this paper is 50.
- The number of marks for each question or part question is shown in brackets [].

Shift
Laboratory

For Examiner's use	
1	/ 7
2	/ 8
3	/ 10
4	/ 17
5	/ 8
Total	/ 50

This paper consists of **20** pages. Any blank pages are indicated.

1 Inorganic Qualitative Analysis

FA 1 is a solution which contains two cations and two anions.

Perform the tests described in Table 1.1 and record your observations in the table.
Test and identify any gases evolved.

Table 1.1

	<i>tests</i>	<i>observations</i>
(a)	(i) To a 2 cm depth of FA 1 solution in a boiling tube, add aqueous sodium hydroxide, slowly with shaking, until 4 cm depth of aqueous sodium hydroxide is added. Gently warm the mixture. Then filter the mixture, collecting the filtrate in a clean test-tube. Leave to stand for several minutes. Keep the filtrate for test (ii) and (iii).	
	(ii) To a 1 cm depth of the filtrate from test (i) in a test-tube, add aqueous barium nitrate dropwise. Then add dilute hydrochloric acid until there is no further change.	
	(iii) To a 1 cm depth of the filtrate from test (i) in a test-tube, add 1 cm depth of aqueous silver nitrate. Add aqueous ammonia to the mixture, with shaking until there is no further change.	

[5]

- (b) By considering the observations made in Table 1.1 and making reference to the *Qualitative Analysis Notes*, identify the cations and the anions present in **FA 1**.

The cations in **FA 1** are _____ and _____.

The anions in **FA 1** are _____ and _____.

[2]

[Total: 7]

2 Organic Qualitative Analysis

In this question, you will deduce the structure of an organic compound, **FA 2**. The molecular formula of **FA 2** is $C_5H_{10}O_2$.

Perform the tests described in Table 2.1, and record your observations in the table. Test and identify any gases evolved. Some observations have been recorded.

Do not use Bunsen burner for heating. Use the hot water provided.

Table 2.1

	tests	observations
(a)	(i) Place about 2 cm depth of aqueous sulfuric acid in a test-tube. To this test-tube, add 10 drops of FA 2 , followed by 1 drop of aqueous potassium manganate(VII). Warm the mixture in the hot water bath for two minutes.	
	(ii) Place about 2 cm depth of aqueous silver nitrate in a test-tube. To this test-tube, add 10 drops of aqueous sodium hydroxide, followed by aqueous ammonia until a clear solution is formed. To this test-tube, add 10 drops of FA 2 . Warm the mixture in the water bath for two minutes.	
	(iii) Place about 1 cm depth of deionised water in a test-tube. To this test-tube, add 10 drops of FA 2 and add 10 drops of aqueous sodium hydroxide. Now add iodine solution dropwise, until a permanent yellow/orange colour is obtained. Warm the mixture in the water bath for two minutes.	

[3]

- (b) (i) When sodium metal and 2,4-dinitrophenylhydrazine are added to separate samples of **FA 2**, effervescence *extinguishes a lighted splint with a “pop” sound* and an *orange precipitate is observed respectively*.

Use this information and the observations recorded in table 2.1, identify **two** functional groups present in **FA 2**.

Give evidence(s) to support your conclusion.

Functional group: _____

Evidence:

[2]

Functional group: _____

Evidence:

[2]

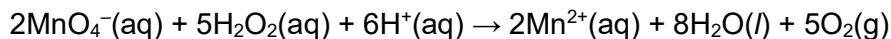
- (ii) Suggest a structure of **FA 2** given that it contains a chiral centre.

[1]

[Total: 8]

3 Determination of the volume strength of hydrogen peroxide

The concentrations of solutions of hydrogen peroxide are often represented in terms of 'volume strength'. In this experiment you will determine the 'volume strength' of a solution of hydrogen peroxide by titration with acidified potassium manganate(VII).



FA 3 is $0.0300 \text{ mol dm}^{-3}$ potassium manganate(VII), KMnO_4 .

FA 4 is aqueous hydrogen peroxide, H_2O_2 .

FA 5 is 1.0 mol dm^{-3} sulfuric acid, H_2SO_4 .

(a) (i) Dilution of FA 4

- Pipette 25.0 cm^3 of **FA 4** into the 250 cm^3 volumetric flask.
- Make the solution up to the mark using deionised water.
- Label this solution of hydrogen peroxide **FA 6**. This is a solution of hydrogen peroxide suitable for titration.

Keep FA 5 and FA 6 for use in Question 4.

Titration of FA 6 against FA 3

1. Fill the burette with **FA 3**.
2. Pipette 25.0 cm^3 of **FA 6** into a conical flask.
3. Use the 50 cm^3 measuring cylinder to add 20.0 cm^3 of **FA 5** into the same conical flask.
4. Run **FA 3** from the burette into the flask. The end-point is reached when the first permanent pink is observed.
5. Record your titration results, to an appropriate level of precision, in the space provided below.
6. Discard the reaction mixture.
7. Repeat steps 2 to 6 until consistent results are obtained.

Titration results

[4]

- (ii) From your titrations, obtain a suitable volume of **FA 3** to be used in your calculations.
Show clearly how you obtained this value.

Volume of **FA 3** = [1]

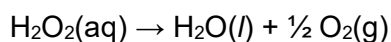
- (b) (i) Calculate the concentration of H_2O_2 in **FA 6**.

Concentration of H_2O_2 in **FA 6** = [3]

- (ii) Calculate the concentration of H_2O_2 in **FA 4**, in mol dm^{-3} .

concentration of H_2O_2 in **FA 4** = mol dm^{-3} [1]

- (iii) When hydrogen peroxide decomposes in the presence of a catalyst, oxygen is produced.



Calculate the volume, in dm^3 , of oxygen produced when 1.00 dm^3 of **FA 4** decomposes. This is the 'volume strength', in vol, of **FA 4**.

(Under room conditions, 1.00 mol of gas occupies a volume of 24.0 dm^3 .)

'volume strength' of **FA 4** = vol [1]

[Total: 10]

4 Investigating the kinetics of the reaction between hydrogen peroxide and iodide ions

FA 5 is 1.0 mol dm⁻³ sulfuric acid, H₂SO₄.

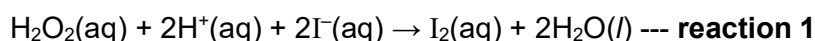
FA 6 is dilute aqueous hydrogen peroxide, H₂O₂, prepared in **Question 3**.

FA 7 is 0.50 mol dm⁻³ potassium iodide, KI.

FA 8 is 0.025 mol dm⁻³ sodium thiosulfate, Na₂S₂O₃.

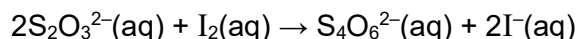
starch indicator

Hydrogen peroxide reacts with iodide ions, I⁻(aq) in acidified medium according to the equation shown.



In this experiment, the rate of reaction is studied by measuring the rate of formation of iodine using a 'clock' method. You will vary the concentration of hydrogen peroxide 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/ purple color in the presence of starch.

Introducing a small limited amount of sodium thiosulfate reduces the iodine produced back to iodide ions. As a result, the blue-black/ purple colour does not appear immediately.



The end-point of the reaction, characterised by the first appearance of the dark blue starch-iodine complex, is observed when the sodium thiosulfate is fully reacted.

You will conduct 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/ purple colour to appear

(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 6**, **FA 7**, **FA 8** and **starch** added and deionised water (*V*_{water}) used
- all values of *t* to nearest seconds
- calculated values of $1/t$
- calculated values of $\lg (1/t)$
- calculated values of $\lg (V_{\text{FA 6}})$.

Experiment 1

1. Use the same 10 cm³ measuring cylinder to transfer the following volumes into a 100 cm³ conical flask.
 - 10.0 cm³ of **FA 5**
 - 10.0 cm³ of **FA 7**
 - 1.0 cm³ of starch indicator
2. Use another 10 cm³ measuring cylinder to transfer 10.0 cm³ of **FA 8** into the same 100 cm³ conical flask.
3. Use a 25 cm³ measuring cylinder to measure 25.0 cm³ of **FA 6**.
4. Add the **FA 6** to the same conical flask, starting the stopwatch during this addition.
5. Mix the content thoroughly by swirling the flask several times. Then place the flask on a white tile.
6. Stop the stopwatch at the first appearance of a blue-black/ purple colour.
7. Record the time taken, to the nearest second, in your table.

Experiment 2 to 5

Repeat experiment 1 four times, adding 20.0 cm³, 17.0 cm³, 13.0 cm³, 10.0 cm³ of **FA 6** respectively in step 3.

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

You should alternate the use of the two 100cm³ conical flasks.

Record all volumes, the time taken and the calculated values of $\frac{1}{t}$, $\lg (\frac{1}{t})$ and $\lg (V_{\text{FA 6}})$ in your table.

Results

- (b) (i) Plot a graph of $\lg(1/t)$ on the y axis against $\lg(V_{FA6})$ on the x-axis on the grid in Fig.4.1. Draw a best-fit straight line.

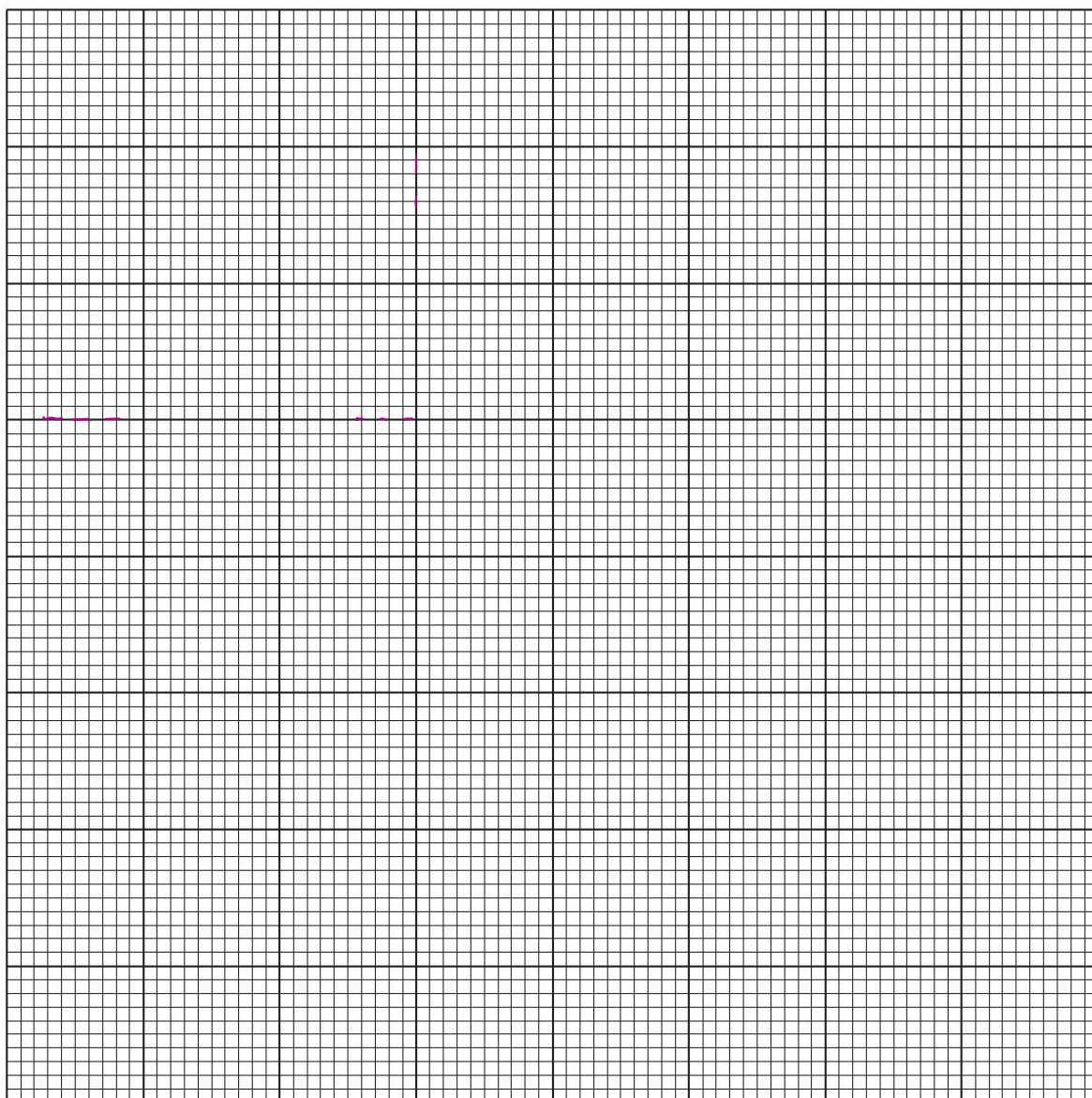


Fig.4.1

[3]

- (ii) Calculate the gradient of the line to three significant figures, showing your working clearly.

Gradient:[1]

- (iii) The gradient of the line gives the order of the reaction with respect to hydrogen peroxide.

Using your answer in (ii), calculate the percentage error given that the order with respect to H_2O_2 is one.

Percentage error =[1]

- (iv) Use your graph to determine the time, t , for the experiment if 16.50 cm^3 of **FA 6** is added.

Time taken =[1]

- (c) Calculate the rate of change of $[\text{S}_2\text{O}_3^{2-}]$ in experiment 1.

[2]

- (d) (i) A student repeated **Experiment 1** but used $0.050 \text{ mol dm}^{-3}$ sodium thiosulfate in place of **FA 8**.

How would this change the percentage error in the recorded time? Explain your answer.

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

- (ii) Another student was unable to complete all four experiments on the same day but had to return to the investigation the following morning. The student noticed that the results were significantly different.

Give one possible reason for these differences and explain how the student could have overcome these problems.

.....
.....
..... [2]

- (e) With reference to the graph plotted in (b)(i), suggest a modification to the procedure to increase reliability of results.

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

[Total: 17]

5 Planning

When magnesium sulfate, MgSO_4 is added to water, an exothermic process occurs.



The maximum temperature change occurring during this reaction may be determined graphically.

To increase the reliability of the experimental results, the temperature change should be kept with the range of 5 to 10°C.

The maximum temperature change, ΔT_{max} , obtained from the graph can be used to calculate the heat change, q , for this experiment.

Using q , a value for the molar enthalpy change of solution, ΔH_{sol} , for magnesium sulfate may be determined.

In this question, you are to plan a procedure that would provide sufficient data to allow you to determine an accurate and reliable value for the molar enthalpy change of solution, ΔH_{sol} , for magnesium sulfate.

- (a) Given that when 17.0 g of MgSO_4 solid is dissolved in 50.0 cm³ of water, the temperature change is measured to be 53.0 °C.

Discuss why this experimental result is unreliable. Hence suggest a suitable mass of MgSO_4 that should be used for this experiment.

mass of solid MgSO_4 = g
[1]

- before the reaction starts,
- during the reaction,
- for some time after the reaction is complete.

- 20 g of magnesium sulfate,
- the equipment normally found in a school or college laboratory.

- the apparatus you would use,
- the quantities you would use, so that there is an appropriate temperature change,
- the measurements you would make to allow a suitable temperature–time graph to be drawn,
- how you would ensure that an accurate and reliable value of $\Delta T_{\max}$ is obtained.

This image shows a full page of white paper with horizontal dashed lines, typical of primary-ruled notebook paper. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

- (c) Sketch, on Fig. 5.1, the graph you would expect to obtain using the measurements you planned to make in **5(b)**.

Show, in your sketch, how the maximum temperature change, ΔT_{max} , can be determined.

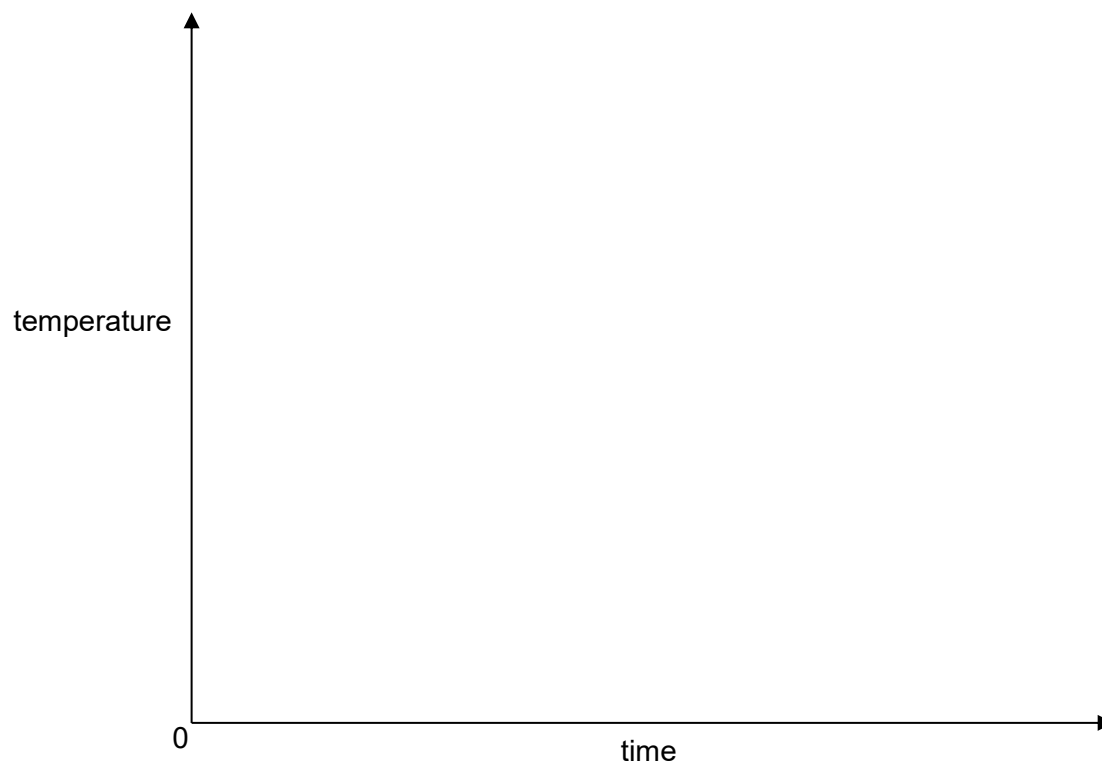


Fig. 5.1

[2]

[Total: 8]

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>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) 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 aq. 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

Organic compounds	reactions
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 white ppt.
Carbonyl compounds (aldehydes and ketones)	• 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 aldehyde) • Gives silver mirror with Tollen's reagent on warming (for aldehydes)
Carboxylic acid	• CO₂ liberated by Na₂CO₃(aq) • Gives white fumes with solid PCl₅
phenylamine	Decolourises orange Br ₂ (aq) and forms white ppt.
Primary amide	NH ₃ liberated on heating with NaOH(aq)

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