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CHEMISTRY

9476/04

Paper 4 Practical

25 August 2026

2 hours 30 minutes

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

- Answer **all** questions.
- Use a black or dark blue pen. You may use a HB pencil for any diagrams or graphs.
- Write your **name**, **CT group**, **centre number** and **index number** on all the work you hand in.
- 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 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	
2	
3	
4	
Total	



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

1 Qualitative Analysis of FA 1

Qualitative Analysis

FA 1 is an aqueous solution containing two cations and one anion.

In addition to having access to the usual bench reagents, you are also provided with the following:
aqueous sodium thiosulfate
aqueous hydrogen peroxide

Carry out the tests described in Tables 1.1 and 1.2.
Carefully record your observations **at each stage** of the tests in the tables.
Test and identify any gases produced.

(a) Cation test

Table 1.1

test		observations
1	To 2 cm depth of FA 1 in a test-tube, add aqueous sodium hydroxide dropwise, until there is no further change. Filter the mixture into a clean boiling tube. Retain both residue and filtrate for tests 2 and 3. While waiting, proceed to 1(c) .	
2	Warm the filtrate from test 1. Let the filtrate cool down, then add dilute sulfuric acid until there is no further change.	
3	Place the filter funnel with the residue from test 1 over a clean test-tube. Carefully add dilute hydrochloric acid, a few drops at a time to dissolve the residue completely. Ensure that you have added enough dilute hydrochloric acid such that the test-tube is half filled. Stir the solution with a glass rod. Retain the resultant solution for tests 4 and 5.	



4	To 1 cm depth of the solution from test 3, in a test-tube, add aqueous potassium iodide dropwise, until there is no further change. Then add aqueous sodium thiosulfate until there is no further change. (ignore any ppt that might form after standing)	
5	To 1 cm depth of the solution from test 3, in a test-tube, add 1 cm depth of aqueous sodium thiosulfate. Shake and observe until there is no further change. Then add aqueous sodium hydroxide until there is no further change. Then add 2 cm depth of aqueous hydrogen peroxide.	

[8]

(b) (i) Identify the two cations in **FA 1**.

cation 1:

cation 2:

[2]



- (ii) Suggest and explain the roles of the following reagents. Support your answer with appropriate observations.

role of aqueous potassium iodide in test 4:

explanation:
.....

role of aqueous hydrogen peroxide in test 5:

explanation:
.....

[2]

(c) Anion test

Table 1.2

test		Observations
1	To 1 cm depth of FA 1 in a test-tube, add 1 cm depth of aqueous silver nitrate. Allow any precipitate formed to settle. Decant the solution. Wash the precipitate with deionised water and discard the washings. Add aqueous ammonia to the precipitate.	

[2]

- (d) Use your observations in (c) to identify the anion in **FA 1**.

anion:

[1]

[Total: 15]



2 To determine the concentration of potassium iodate(V)

You are provided with the following.

FA 2 is a solution containing potassium iodate(V), KIO_3 .

FA 3 is 1.00 mol dm^{-3} sulfuric acid, H_2SO_4 .

FA 4 is 0.50 mol dm^{-3} potassium iodide, KI .

FA 5 is approximately 0.1 mol dm^{-3} sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$.

Starch indicator

You are to determine the concentration of potassium iodate(V) present in **FA 2**.

In acidic conditions, potassium iodate(V) oxidises iodide ions to iodine. Titration of this iodine with a standard solution of sodium thiosulfate allows the concentration of potassium iodate(V) to be determined.



FA 2 is too concentrated for use directly. You will therefore prepare a diluted solution of **FA 2**.

You will then use **FA 5** to determine the concentration of potassium iodate(V) in the diluted solution by titration, and hence determine the concentration of potassium iodate(V) in **FA 2**.

(a) Dilution of FA 2

- Using a burette, measure between 49.00 cm^3 and 49.50 cm^3 of **FA 2** into a 250 cm^3 volumetric flask.

Record your burette readings and the volume of **FA 2** used in Table 2.1.

Table 2.1

Final burette reading / cm^3	
Initial burette reading / cm^3	
Volume of FA 2 used / cm^3	

- Make up the contents of the flask to the 250 cm^3 mark with deionised water. Place the stopper in the flask and mix the contents thoroughly. This solution is **FA 6**.



(b) (i) **Titration of FA 6 with FA 5**

1. Fill a clean burette with **FA 5**.
2. Pipette 25.0 cm^3 of **FA 6** into a conical flask.
3. Use appropriate measuring cylinders to add to this flask
 - 20 cm^3 of **FA 3**,
 - 10 cm^3 of **FA 4**.
4. Run **FA 5** from the burette into the flask until the solution becomes pale yellow.
5. Add about 10 drops of starch indicator to this flask and continue adding **FA 5** until the blue-black colour **just** disappears.
6. Record your titration results in Table 2.2. Make certain that your recorded results show the precision of your working.
7. Repeat steps 2-6 until consistent results are obtained.

Results

Table 2.2

Final burette reading / cm^3					
Initial burette reading / cm^3					
Volume of FA 5 used / cm^3					

[4]

- (ii) From your titrations results, obtain a suitable volume of **FA 5** to be used in your calculations. Show clearly how you obtained this volume.

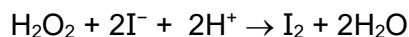
volume of **FA 5** = [1]



(c) **Standardisation of FA 5** (You are **not** required to carry out this experiment.)

The solution of sodium thiosulfate, **FA 5**, you are provided with is approximately 0.1 mol dm^{-3} . The exact concentration has been determined by titrating it with a standard solution of 0.750 volume hydrogen peroxide.

In acidic conditions, hydrogen peroxide oxidises iodide ions to iodine.



reaction 3

The liberated iodine is then titrated against **FA 5**. The procedure used is given below.

- A burette was filled with **FA 5**.
- 25.0 cm^3 of the hydrogen peroxide was pipetted into a conical flask.
- 50 cm^3 of **FA 3** and 20 cm^3 of **FA 4** were added to the conical flask.
- About 6 drops of ammonium molybdate was added as a catalyst as **reaction 3** is slow.
- **FA 5** was added from the burette to the flask until the solution became pale yellow.
- 10 drops of starch indicator were added to the flask.
- More **FA 5** was added from the burette to the flask until the blue-black colour **just** disappeared.

The volume of **FA 5** added was 31.50 cm^3 .

(d) (i) Hydrogen peroxide decomposes to form water and oxygen gas only.

The concentration of hydrogen peroxide solution is often expressed as a *volume strength*.

This term refers to the volume of oxygen evolved at room temperature and pressure when the hydrogen peroxide in 1.00 cm^3 of solution is fully decomposed.

For example, *10 volume* hydrogen peroxide produces 10 cm^3 of oxygen gas at room temperature and pressure from 1.00 cm^3 of the solution.

Show that the concentration of hydrogen peroxide used for the standardisation of **FA 5** was $0.0625 \text{ mol dm}^{-3}$.

(The molar volume of a gas at room temperature and pressure = $24.0 \text{ dm}^3 \text{ mol}^{-1}$.)

[2]



- (ii) Calculate the concentration, in mol dm^{-3} , of sodium thiosulfate in **FA 5**.

[$\text{Na}_2\text{S}_2\text{O}_3$] in **FA 5** = mol dm^{-3} [2]

- (iii) Calculate the concentration, in mol dm^{-3} , of potassium iodate(V) in **FA 6**.

[KIO_3] in **FA 6** = mol dm^{-3} [2]

- (iv) Calculate the concentration, in mol dm^{-3} , of potassium iodate(V) in **FA 2**.

[KIO_3] in **FA 2** = mol dm^{-3} [2]

[Total: 13]



3. To determine the order of reaction with respect to H_2O_2

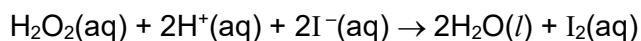
You are provided with the following.

FA 3 is 1.00 mol dm^{-3} sulfuric acid.

FA 7 is $0.0050 \text{ mol dm}^{-3}$ hydrogen peroxide solution.

FA 8 contains starch (0.20 g), potassium iodide (8.00 g) and sodium thiosulfate (0.40 g) in 1 dm^3 of water.

In an acidic condition, hydrogen peroxide reacts with iodide ions according to the equation below.



When an acidified solution of hydrogen peroxide is mixed with a solution containing potassium iodide, starch and sodium thiosulfate, the colourless mixture suddenly turns dark blue after a few seconds. This is one version of what are known as iodine clock experiments.

The order of the reaction with respect to hydrogen peroxide may be determined by performing a number of experiments and then graphically analysing the results.

Note: The measuring equipment used for the experiments described below must be kept separate. Under no circumstances should the equipment used with one solution be used to measure another solution.

- (a) Prepare a table in the space provided on page 10 in which to record, to an appropriate degree of precision:
- the volumes of **FA 3** (V_{FA3}), **FA 7** (V_{FA7}), **FA 8** (V_{FA8}) and deionised water used.
 - all values of t
 - calculated values of $1/t$ to 3 significant figures.

Experiment 1

1. Measure 50.0 cm^3 of **FA 8** using a 50 cm^3 measuring cylinder and transfer the solution into a 250 cm^3 beaker.
2. Measure 25.0 cm^3 of **FA 7** using a 25 cm^3 measuring cylinder and transfer the solution into a clean 100 cm^3 beaker.
3. Using another 50 cm^3 measuring cylinder, measure 25.0 cm^3 of **FA 3** and pour it into the same 100 cm^3 beaker.
4. Pour all the solution in this 100 cm^3 beaker into the 250 cm^3 beaker containing **FA 8** rapidly and **at the same moment** start a stopwatch.
5. Swirl the beaker to ensure mixing and stop the stopwatch when the colourless mixture turns dark blue. Record the time taken, t , to the nearest second in your table.
6. Empty and wash the beakers thoroughly.



Experiment 2

1. Measure 50.0 cm^3 of **FA 8** using a 50 cm^3 measuring cylinder and transfer the solution into a 250 cm^3 beaker.
2. Measure 5.0 cm^3 of **FA 7** using a 25 cm^3 measuring cylinder and transfer the solution into a clean 100 cm^3 beaker.
3. Using a 50 cm^3 measuring cylinder, measure 25.0 cm^3 of **FA 3** and pour it into the same 100 cm^3 beaker.
4. Using a 25 cm^3 measuring cylinder, measure 20.0 cm^3 of **deionised water** and pour it into the same 100 cm^3 beaker.
5. Pour all the solution in the 100 cm^3 beaker into the 250 cm^3 beaker containing **FA 8** rapidly and **at the same moment** start a stopwatch.
6. Swirl the beaker to ensure mixing and stop the stopwatch when the colourless mixture turns dark blue. Record the time taken, t , to the nearest second in your table.
7. Empty and wash the beakers thoroughly.

Experiment 1 and 2 gives the time taken for the 'fastest' and 'slowest' reaction respectively.

Experiments 3 to 5

Repeat Experiment 2 **three** times. In each experiment, you should adjust the volume of deionised water in step 4 to ensure the **same total volume** of reaction mixture is used.

You should also ensure **only** the concentration of **FA 7** is varied, so that t falls between that of Experiments 1 and 2.

Record all volumes, the time taken and the calculated values of $1/t$ in your table.

Results

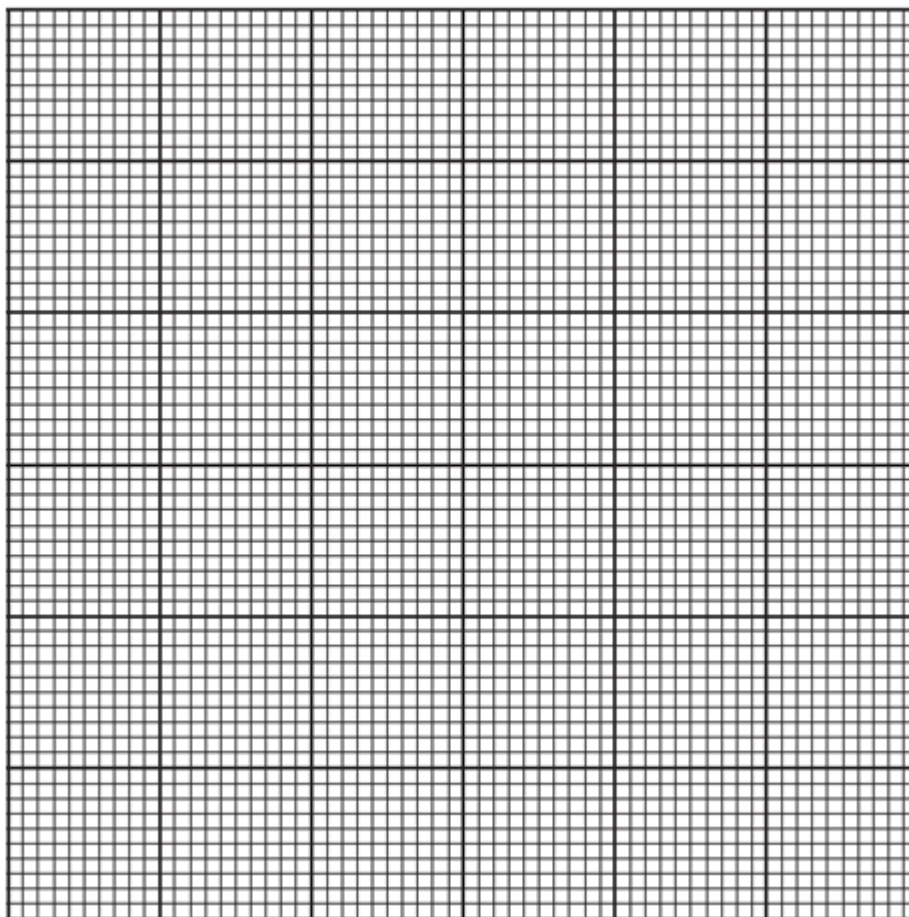
[5]



- (b) The total volume of the reaction mixture in all the 5 experiments should be kept constant. What is the advantage of keeping the total volume constant?

.....
 [1]

- (c) On the grid below, plot a graph of $\frac{1}{t}$ on the y-axis, against V_{FA7} on the x-axis. Draw a line of best-fit.



[3]

- (d) From your graph, deduce the order of reaction with respect to H_2O_2 . Explain your reasoning.

.....

 [2]

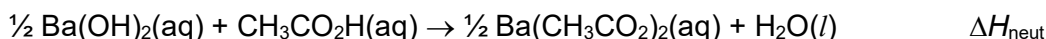
- (e) Given that the reaction is first order with respect to both H^+ and I^- , determine the units of the rate constant.

[1]

[Total: 12]



- 4 The enthalpy change of neutralisation, ΔH_{neut} , of barium hydroxide, $\text{Ba}(\text{OH})_2(\text{aq})$, with ethanoic acid, $\text{CH}_3\text{CO}_2\text{H}(\text{aq})$, is the molar enthalpy change for the reaction below.



- (a) Assume you are given the following solutions:

- $0.50 \text{ mol dm}^{-3} \text{Ba}(\text{OH})_2(\text{aq})$;
- $\text{CH}_3\text{CO}_2\text{H}(\text{aq})$ of approximately the same concentration.

The two solutions are mixed together to give a total volume of 50 cm^3 .

Determine the approximate volumes of $\text{Ba}(\text{OH})_2(\text{aq})$ and of $\text{CH}_3\text{CO}_2\text{H}(\text{aq})$ to be used such that both react completely. Give your answers to the **nearest whole number**.

[1]

A series of experiments can be carried out using different volumes of the two solutions. In each experiment, the total volume of the two solutions is to be kept at 50 cm^3 and the increase in temperature, ΔT , is to be determined.

A graph of ΔT against *volume of $\text{CH}_3\text{CO}_2\text{H}(\text{aq})$* can then be used to determine the concentration of the $\text{CH}_3\text{CO}_2\text{H}(\text{aq})$ and ΔH_{neut} .

- (b) Plan a procedure to collect sufficient data to allow a graph of ΔT against *volume of $\text{CH}_3\text{CO}_2\text{H}(\text{aq})$* to be drawn.

You may assume that you are provided with:

- $0.50 \text{ mol dm}^{-3} \text{Ba}(\text{OH})_2(\text{aq})$,
- $\text{CH}_3\text{CO}_2\text{H}(\text{aq})$ of approximately the same concentration,
- the equipment normally found in a school laboratory.

Your plan should include the following:

- a table to show the different volumes of $\text{CH}_3\text{CO}_2\text{H}(\text{aq})$ and $\text{Ba}(\text{OH})_2(\text{aq})$ to be used and the temperature data needed,
- essential experimental details including the apparatus you would use,
- a description of how you would minimise heat loss.

You may assume that the $\text{CH}_3\text{CO}_2\text{H}(\text{aq})$ and $\text{Ba}(\text{OH})_2(\text{aq})$ solutions have the same initial temperature.

.....
.....



..... [5]



(c) Figure 4.1 shows the graph that would be obtained from this experiment.

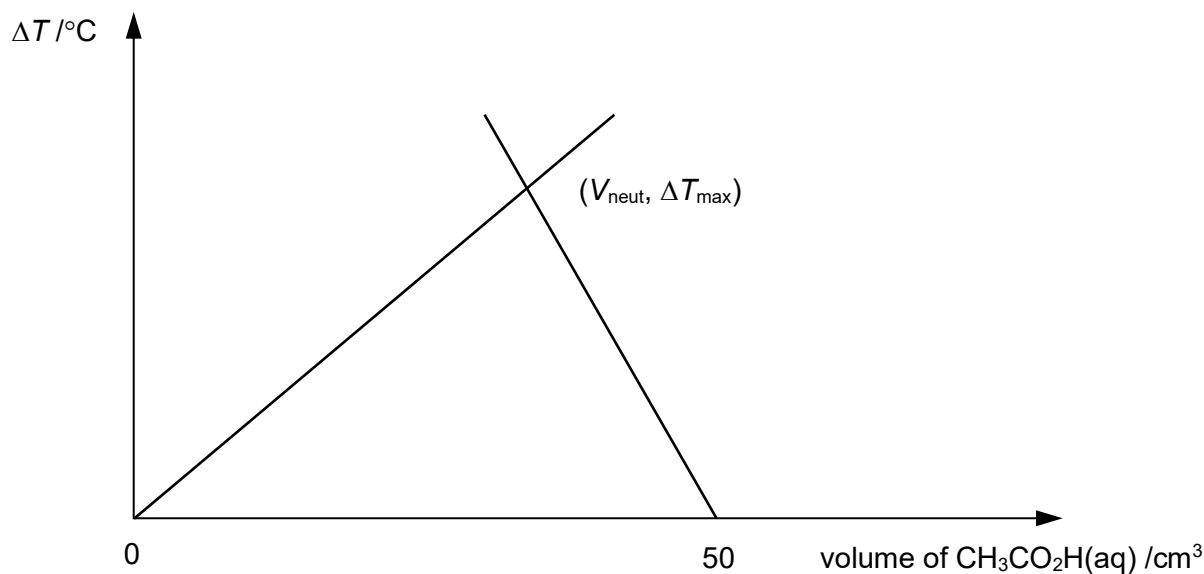


Figure 4.1

- (i) Write calculation steps to show how you would use this graph to determine
- the concentration of $\text{CH}_3\text{CO}_2\text{H(aq)}$, in mol dm^{-3} ,
 - ΔH_{neut} .

You may assume the following:

- specific heat capacity of all solutions is $4.18 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$,
- density of all solutions is 1.00 g cm^{-3} .

[2]

- (ii) Explain the effect on V_{neut} and on ΔT_{max} if $\text{CH}_3\text{CO}_2\text{H(aq)}$ was changed to HCl(aq) of the same concentration.

.....

.....

.....

.....

[2]

[Total: 10]

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**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) 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) Tests for organic compounds**

organic compounds	reactions
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 by $\text{Na}_2\text{CO}_3(\text{aq})$ • 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 $\text{NaOH}(\text{aq})$