



VICTORIA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE
NAME

CT GROUP

CHEMISTRY

9476/04

Paper 4 Practical

19 August 2026

You must answer on the question paper.

2 hours 30 minutes

You will need: The materials and apparatus listed in the confidential instructions

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 and CT group on the lines 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.
- 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.
- You may lose marks if you do not show your working or if you do not use appropriate units.

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	/ 13
2	/ 15
3	/ 12
4	/ 10
Total	/ 50

This document consists of **16** printed pages.

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

1 Determination of the percentage purity of a sample of calcium carbonate, CaCO_3

FA 1 is impure calcium carbonate, CaCO_3 .

FA 2 is 2.00 mol dm^{-3} hydrochloric acid, HCl .

FA 4 is $0.150 \text{ mol dm}^{-3}$ sodium hydroxide, NaOH .

Thymolphthalein indicator is also provided.

This experiment involves three steps.

Step 1: A known mass of the impure calcium carbonate, **FA 1**, is reacted with an excess of hydrochloric acid, **FA 2**.

Step 2: You will dilute the products of step 1 to 250 cm^3 in a volumetric flask. This solution is **FA 3**.

Step 3: You will carry out titrations to find out how much acid remains after the reaction in step 1.

- (a) (i) In the space provided on page 3, prepare tables in which to record for your experiment:
- all weighings, to an appropriate level of precision
 - the mass of **FA 1** used in the reaction
 - titration results, to an appropriate level of precision

Procedure

1. Pipette 25.0 cm^3 of **FA 2** into a 250 cm^3 beaker.
2. Weigh the capped container containing solid **FA 1**. Record the mass.
3. Transfer all the solid **FA 1** gradually into the 250 cm^3 beaker. Vigorous effervescence and some spraying of the acid on the sides of the beaker will occur. Stir the mixture with a glass rod to dissolve **FA 1** completely. Reweigh and record the mass of the emptied capped container.
4. Transfer the solution into a 250 cm^3 volumetric flask quantitatively. Rinse the beaker and the glass rod with deionised water. Pour the washings into the volumetric flask.
5. Make the solution up to the mark with deionised water. Thoroughly mix the contents of the volumetric flask. Label this solution **FA 3**.
6. Fill a burette with **FA 4**.
7. Rinse the 10.0 cm^3 pipette with deionised water and then with **FA 3**.
8. Pipette 10.0 cm^3 of **FA 3** into a 250 cm^3 conical flask.
9. Add 2 to 3 drops of thymolphthalein.
10. Run **FA 4** from the burette into the conical flask. The end-point is reached when the first permanent blue colour, lasting at least 15 seconds, is seen throughout the solution.
11. Record your titration results, to an appropriate level of precision.

12. Discard the reaction mixture via the sink.
13. Repeat steps 8 to 12 until consistent results are obtained.

[6]

- (ii) From your titrations, obtain a suitable volume of **FA 4** to be used in your calculations. Show clearly how you obtained this volume.

Volume of **FA 4** = cm³ [1]

- (b) (i) Calculate the amount, in mol, of sodium hydroxide in the volume of **FA 4** in (a)(ii).

amount of NaOH = mol [1]

- (ii) Use your answer to (b)(i) to calculate the amount, in mol, of hydrochloric acid in 250 cm³ of **FA 3**.

amount of HCl in 250 cm³ of **FA 3** = mol [1]

- (iii) Use your answers to (b)(ii) to calculate the amount, in mol, of hydrochloric acid that reacted with the **FA 1** in step 1.

amount of HCl that reacted with **FA 1** = mol [1]

- (iv) Use your answer to (b)(iii) and the mass of **FA 1** used to calculate the percentage purity of calcium carbonate. Show your working.
[A_r: Ca, 40.1; C, 12.0; O, 16.0]



percentage purity of CaCO₃ = % [3]

[Total: 13]

2 Investigation of the kinetics of an acid-catalysed reaction between propanone and iodine

FA 2 is 2.00 mol dm^{-3} hydrochloric acid, HCl .

FA 5 is 1.00 mol dm^{-3} propanone, CH_3COCH_3 .

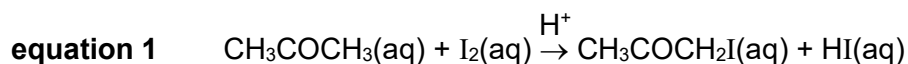
FA 6 is an aqueous solution of iodine, I_2 .

FA 7 is $0.0100 \text{ mol dm}^{-3}$ sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$.

FA 8 is aqueous sodium carbonate, Na_2CO_3 .

Starch indicator is also provided.

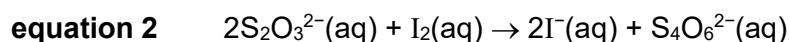
The iodination of propanone to form iodopropanone proceeds as shown in equation 1. This reaction is catalysed by hydrogen ions.



You are to investigate the order of reaction with respect to I_2 .

A reaction mixture containing **FA 2**, **FA 5** and **FA 6** is first prepared. At different chosen times, aliquots (portions) of this reaction mixture are removed and quenched with excess **FA 8**.

The remaining I_2 in the aliquot reacts with $\text{S}_2\text{O}_3^{2-}$ as shown in equation 2.



It is necessary that you titrate each aliquot against **FA 7** before transferring the next aliquot.

The required order of reaction can be obtained by graphical analysis of your results.

(a) Preparation and titration of the reaction mixture.

Note: You will perform each titration once only. Great care must be taken that you do not overshoot the end point.

Once you have started the stopwatch, it must continue running for the duration of the experiment. You must not stop it until you have finished the experiment.

You should aim not to exceed a maximum reaction time of 20 minutes for this experiment.

In an appropriate format in the space provided on page 6, prepare a table in which to record for each aliquot

- the time of transfer, t , in minutes and seconds,
- the decimal time, t_d , to 0.1 min, for example, if $t = 4 \text{ min } 33 \text{ s}$ then $t_d = 4 \text{ min} + 33/60 \text{ min} = 4.6 \text{ min}$
- the burette readings and the volume of **FA 7** added.

1. Rinse the 10.0 cm³ pipette with deionised water and keep it for step 6.
2. Fill a burette with **FA 7**.
3. Using a 50 cm³ measuring cylinder, measure 25 cm³ of **FA 5** into a conical flask. This conical flask contains the reaction mixture.
4. Pipette 25.0 cm³ of **FA 2** into the same conical flask.
5. Using a 100 cm³ measuring cylinder, measure 50 cm³ of **FA 6** into the same conical flask. Start the stopwatch. Swirl the mixture thoroughly to mix its contents.
6. Rinse the 10.0 cm³ pipette with the reaction mixture.
7. Pipette a 10.0 cm³ aliquot of the reaction mixture to a second conical flask.
8. Using a 25 cm³ measuring cylinder, measure 20 cm³ of **FA 8**. Transfer this volume of **FA 8** into the second conical flask and vigorously swirl the mixture. Read and record the time of transfer in minutes and seconds, to the nearest second.
9. Immediately titrate the 10.0 cm³ aliquot in the second conical flask with **FA 7**. When colour of the solution turns pale yellow, add about 5 drops of starch. The solution will turn dark blue-black. The end-point is reached when the dark blue/black colour **just** disappears.
10. Wash out the conical flask with water.
11. Repeat steps 7 to 10 until a total of five aliquots have been titrated and their results are recorded.

Results

- (b) (i) Plot a graph of the volume of sodium thiosulfate, **FA 7**, added on the y-axis, against decimal time, t_d , on the x-axis on the grid in Fig. 2.1.

Draw the most appropriate best-fit line considering all your plotted points.

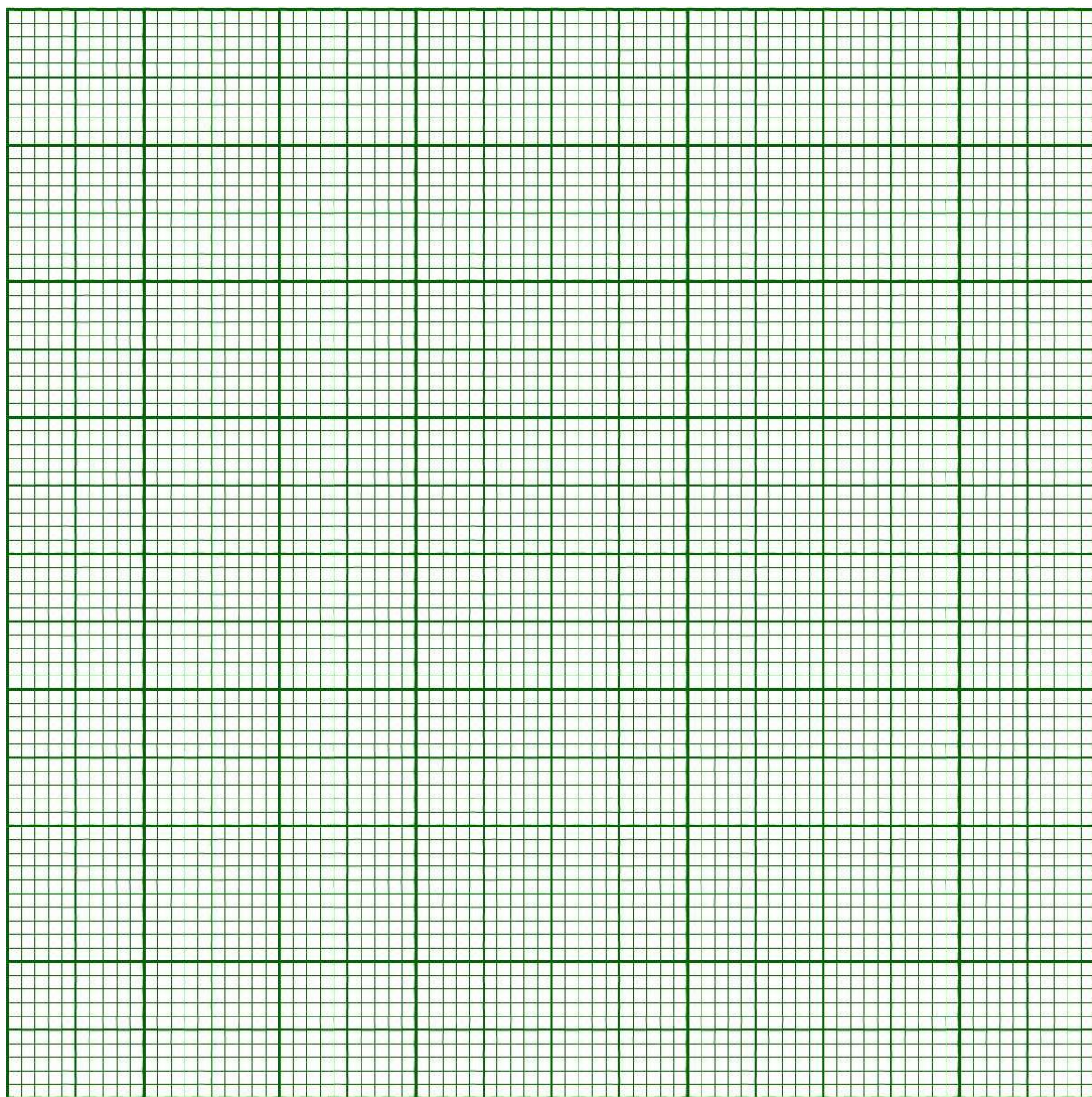


Fig. 2.1

[3]

- (ii) Deduce the order of reaction with respect to the $[I_2]$ in the reaction. Explain your answer.

Order:

Explanation:

.....

.....

..... [1]

- (c) The order of reaction with respect to propanone and hydrogen ion can be either zero order or first order. The procedure in (a) can be modified to determine the order of reaction with respect to propanone and hydrogen ion.
- (i) Complete Table 2.1 such that another two experiments can be carried out using the procedure in (a).

Table 2.1

	volume of water used / cm ³	volume of FA 2 used / cm ³	volume of FA 5 used / cm ³	volume of FA 6 used / cm ³
Experiment 2: To determine order of reaction for propanone				
Experiment 3: To determine order of reaction for hydrogen ion				

[1]

- (ii) Show how the results can be used to determine the order of reaction with respect to propanone and hydrogen ion.

.....

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.....

.....

..... [2]

- (iii) The iodination of propanone is first order with respect to both propanone and hydrogen ion. Using this information and your answer to (b)(ii), write an expression for the rate equation for this reaction.

..... [1]

- (iv) Propanone reacts with bromine via the same mechanism as that with iodine.

Suggest how the rate of reaction between propanone and bromine would compare to that between propanone and iodine of the same concentrations and reaction conditions.

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.....

..... [1]

- (d) Suggest which titration in (a) has the greatest error in its titre value. Explain your answer.

.....

..... [1]

[Total: 15]

3 Qualitative analysis

(a) **FA 9** is an aqueous solution containing two cations and one anion from the ions listed in the *Qualitative Analysis Notes*.

(i) Carry out the tests in Table 3.1 and record your observations. Test and identify any gases evolved.

Table 3.1

test		observations
1	To 1 cm depth of FA 9 , add FA 8 , aqueous sodium carbonate, gradually until no further change.	
2	To 1 cm depth of FA 9 , add aqueous ammonia with shaking, until the aqueous ammonia is in excess.	
	Filter the mixture into a clean test-tube containing 2 cm depth of dilute nitric acid. Keep the resultant solution collected in the test-tube for test 3 and the residue for test 4.	
3	To 2 cm depth of the resultant solution collected in test 2, add aqueous silver nitrate, followed by aqueous ammonia.	
4	Place the filter funnel containing the residue obtained in test 2 in a clean test-tube. Carefully add dilute sulfuric acid to the residue and collect about 2 cm depth of filtrate in the test-tube.	
	To the filtrate, add an equal volume of aqueous potassium iodide, followed by a few drops of starch.	

[6]

- (ii) Identify the two cations and one anion present in **FA 9**.

Cations are and

Anion is [2]

- (iii) Explain the observation when aqueous potassium iodide is added to the filtrate in test 4, in terms of the chemistry involved.

.....

.....

..... [1]

- (b) **FA 10**, $C_4H_8O_2$, gives a yellow precipitate when warmed with alkaline aqueous iodine.

- (i) Carry out the tests in Table 3.2 and record your observations.

Table 3.2

test		observations
5	To 1 cm depth of dilute sulfuric acid in a clean test-tube, add 1 drop of aqueous potassium manganate(VII). Then add 1 cm depth of FA 10 . Place the test-tube in a hot water bath for 2 minutes.	
6	Add 10 drops of $AgNO_3(aq)$ in a clean test-tube. Add 1 drop of $NaOH(aq)$. Add $NH_3(aq)$ dropwise, shaking after each addition, until the brown precipitate just dissolves. Add 10 drops of FA 10 and place the test-tube in a hot water bath for 2 minutes	

[2]

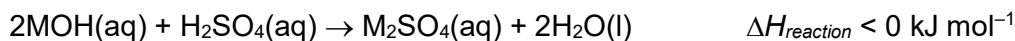
- (ii) Suggest a possible structural formula for **FA 10**.

FA 10: [1]

[Total: 12]

4 Planning

M is a Group 1 metal. The reaction between sulfuric acid and MOH is exothermic.



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 60 cm^3 and the increase in temperature, ΔT , is to be determined.

A graph of ΔT against volume of MOH can be used to determine the volumes needed for complete neutralisation and ΔT_{max} . The concentration of MOH and $\Delta H_{\text{reaction}}$ can then be calculated.

You may assume that you are provided with

- $0.10 \text{ mol dm}^{-3} \text{ H}_2\text{SO}_4$,
- MOH of approximately the same concentration,
- the equipment normally found in a school or college laboratory.

(a) The two solutions are mixed together to give a total volume of 60 cm^3 .

Suggest the volume of H_2SO_4 and the volume of MOH to be used such that both react completely. Show your working clearly and give your answer to the **nearest whole number**.

[1]

(b) Write a plan to collect **six** sets of data to allow a graph of ΔT against volume of MOH to be drawn.

In your plan, you should include details of

- the apparatus you would use
- the volume of MOH and the volume of H_2SO_4 that you would use for **each** experiment
- the temperature measurements you would make to allow a suitable ΔT -volume graph to be drawn
- the procedure you would follow
- how you would ensure accuracy of the results

You may assume that the H_2SO_4 and MOH solutions have the same initial temperature.

- (c) Sketch on Fig. 4.1, the graph you would expect to obtain from your results. Label ΔT_{max} and V_{neu} , the volume of MOH needed for neutralisation.

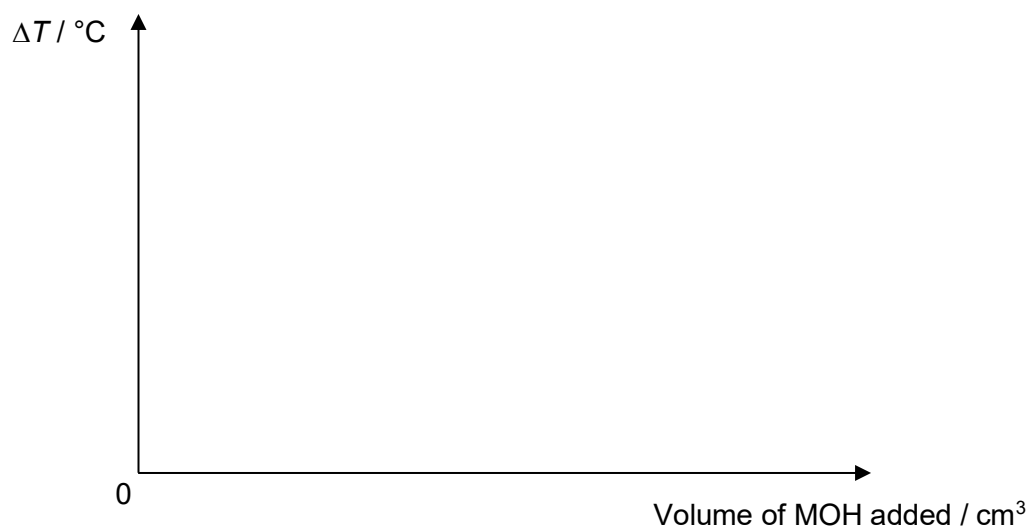


Fig. 4.1

[2]

- (d) Show how you would use ΔT_{max} and V_{neu} to determine $\Delta H_{reaction}$.

You may assume the specific heat capacity of all solutions is $4.2 \text{ J cm}^{-3} ^\circ\text{C}^{-1}$.

[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

(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 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 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 forms a white ppt.
primary amide	NH ₃ liberated on heating with NaOH(aq)