



EUNOIA JUNIOR COLLEGE
JC2 Preliminary Examination 2026
General Certificate of Education Advanced Level
Higher 2

CANDIDATE
NAME

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CIVICS
GROUP

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CHEMISTRY

9476/04

Paper 4 Practical

20 August 2026
2 hour 30 minutes

Candidates answer on the Question Paper

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and registration number on 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 paper clips, highlighters, 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.

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	/11
2	/12
3	/17
4	/10
Total	/50

This document consists of **19** printed pages and **1** blank page.

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

1 Investigation of an organic compound and an inorganic compound

FA 1 is an aqueous solution of an organic compound, **Y**, which contains two different functional groups.

FA 2 contains two cations and one anion.

You will perform tests to identify:

- the functional groups in **Y** and hence deduce its possible structure
- the ions present in **FA 2**.

Unless otherwise stated, the volumes given in Table 1.1 and 1.2 are approximate and should be estimated rather than measured.

Test and identify any gases evolved.

If there is no observable change, write **no observable change**.

(a) (i) Carry out the tests described in Table 1.1.

Carefully record your observations at each stage of the tests in Table 1.1.

Table 1.1

tests		observations
1	To a 1 cm depth of dilute sulfuric acid in a test-tube, add 4 drops of potassium manganate (VII). Then add 1 cm depth of FA 1 . Allow to stand in a hot water bath for two minutes, with occasional shaking.	
2	Add 1 cm depth of FA 1 followed by equal volume of aqueous sodium hydroxide. Then slowly add 1 cm depth of iodine solution. Warm the mixture in the hot water bath if necessary.	
3	To a 2 cm depth of FA 1 in a test-tube, add one spatula full of solid sodium carbonate.	

[3]

- (ii) **Y** is a compound that has three carbon atoms and contains the elements carbon, hydrogen and oxygen only. Draw the structure of **Y**. Use your observations in Table 1.1.

[1]

- (b) (i) Carry out the tests described in Table 1.2.
Carefully record your observations at each stage of the tests in Table 1.2.

Table 1.2

tests		observations
4	Add 1 cm depth of FA 2 to a clean boiling tube. Add sodium hydroxide until there is no further change. Warm the mixture.	
5	Add 1 cm depth of FA 2 to a clean test-tube. Add aqueous ammonia until there is no further change.	
6	Add 1 cm depth of FA 2 to a clean test-tube. Add 5 drops of aqueous silver nitrate.	
	Add aqueous ammonia to the mixture, with shaking, until the aqueous ammonia is in excess.	

[4]

- (ii) Deduce the identity of the two cations in **FA 2** using your results in (b)(i).

..... [2]

- (iii) Explain why it is difficult to identify the anion in **FA 2** from the tests in (b)(i).

.....

 [1]

[Total: 11]

2 Investigating the kinetics of the reaction between iron(III) ions and iodide ions

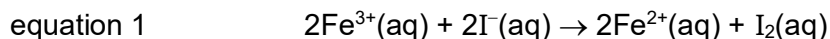
FA 3 is $0.0500 \text{ mol dm}^{-3}$ potassium iodide, KI.

FA 4 is $0.00500 \text{ mol dm}^{-3}$ sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$.

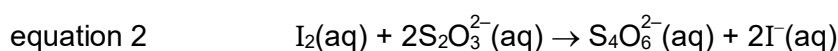
FA 5 is $0.0500 \text{ mol dm}^{-3}$ aqueous iron(III) chloride, FeCl_3 .

You are also provided with a starch indicator.

Iron(III) ions, Fe^{3+} , can oxidise iodide ions, I^- to iodine, I_2 as shown in equation 1.



The initial rate of the reaction can be approximated by adding a small, fixed amount of thiosulfate ions, $\text{S}_2\text{O}_3^{2-}$. As the iodine is produced, it reacts immediately with the thiosulfate ions and is reduced back to iodide ions as shown in equation 2.



Once all thiosulfate ions have reacted, the concentration of iodine rapidly increases. The presence of starch in the reaction mixture leads to the formation of a dark blue coloration, indicating the formation of an iodine-starch complex.

In this experiment, the rate of the reaction is studied by measuring the time taken for the mixture to turn blue-black.

You will perform a series of five experiments. Then, you will graphically analyse your results to determine the order with respect to the concentration of iron(III) ions, $[\text{Fe}^{3+}]$.

For each experiment, you will vary the volume of **FA 5** added, $V_{\text{FA 5}}$, and measure the time taken, t , for the dark blue colour to first appear. The total volumes of the reaction mixture must be kept the same as that used in **experiment 1**, by adding deionised water as required.

Prepare a table in the space provided on page 6 in which to record, to an appropriate degree of precision for each experiment:

- the volumes of **FA 5** ($V_{\text{FA 5}}$), and deionised water
- all values of t
- calculated values of $\log(1/t)$
- calculated values of $\log(V_{\text{FA 5}})$.

(a) Experiment 1

- step 1 Use a 25 cm³ measuring cylinder to measure the following into a 100 cm³ conical flask:
- 10.0 cm³ of **FA 3**
 - 20.0 cm³ of **FA 4**
 - 10.0 cm³ of starch
- step 2 Swirl the contents of the conical flask gently to ensure mixing.
- step 3 Use the measuring cylinder labelled **FA 5** to transfer 20.0 cm³ of **FA 5** to the conical flask. Start the stopwatch when about half of the **FA 5** solution has been added.
- Ignore any initial colouration on mixing.
- step 4 Mix the contents thoroughly by swirling the flask several times before leaving the flask to stand on a white tile.
- step 5 Stop the stopwatch when the solution **first** turns blue-black.
- step 6 Record the time taken, t , to the nearest second, in your table.
- step 7 Wash the flask thoroughly with tap water and then deionised water. Stand the flask upside down on a paper towel to drain.

Experiment 2

Repeat experiment 1, but add both 5.0 cm³ of **FA 5** and 15.0 cm³ of deionised water to the measuring cylinder labelled **FA 5** in step 3 before transferring into the conical flask.

Experiment 3 to 5

Repeat the experiment another three times with different volumes of **FA 5**. The volume of **FA 5** chosen should be between 5.0 cm³ and 20.0 cm³.

In each experiment, you should add deionised water to the measuring cylinder labelled **FA 5** in step 3 to ensure the **same total volume** of reaction mixture is used.

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

Record all required volumes, time taken and calculated values in your table.

Results

[5]

- (b) (i) Plot a graph of $\log(1/t)$ on the y -axis against $\log(V_{FA\ 5})$ on the x -axis on the grid in Figure 2.1. Draw the best-fit straight line.

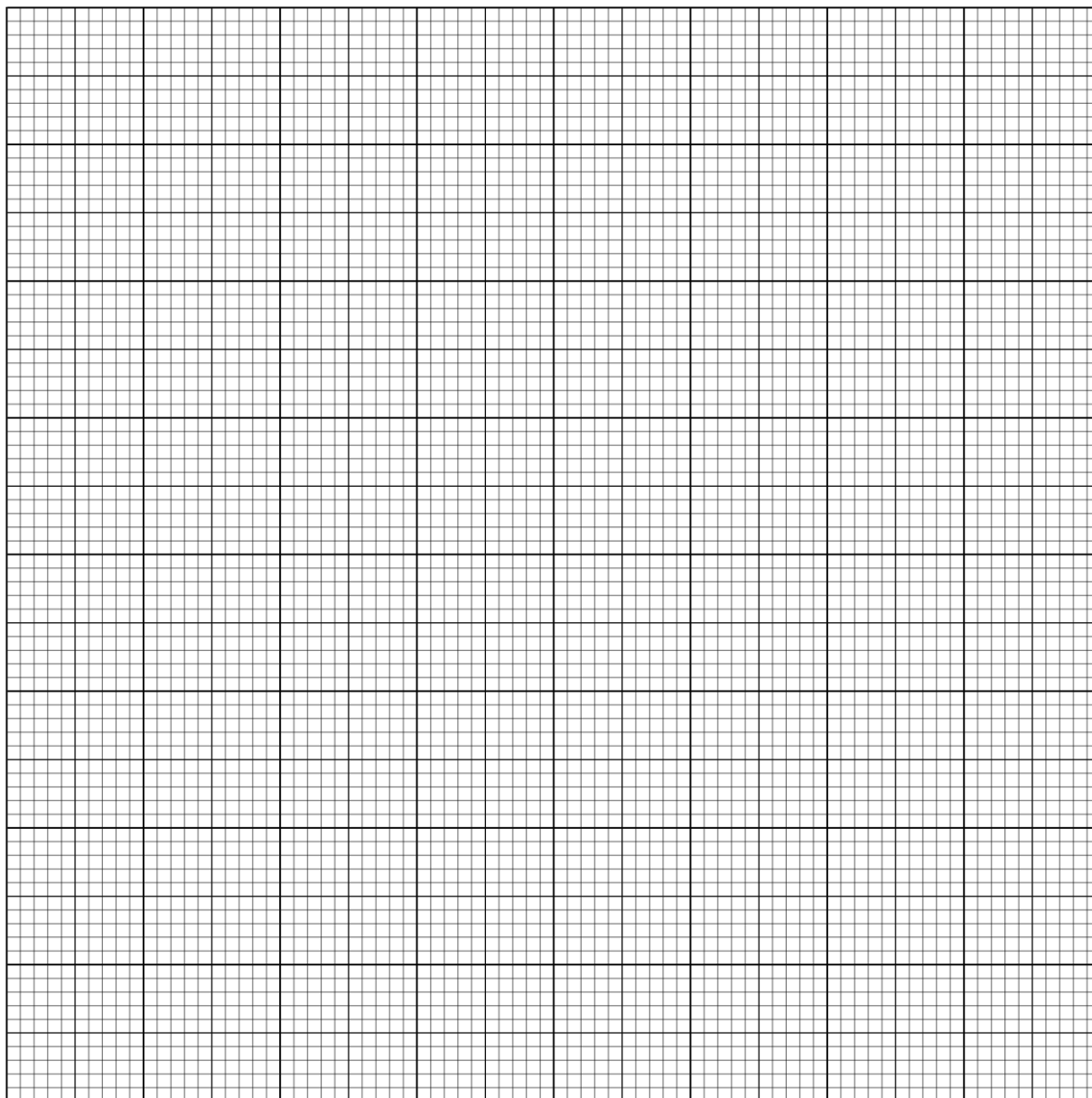


Figure 2.1

[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 iron(III) ions. The reaction is first order with respect to iron(III) ions. Calculate the percentage error in your value of gradient.

Percentage error = [1]

- (c) A student correctly carried out the method in (a), but used a more concentrated solution of sodium thiosulfate, **FA 4**.

State and explain the likely effect on t when a more concentrated solution of sodium thiosulfate is used.

effect of t

explanation

.....

.....

[1]

- (d) A student thinks that the reaction is second order with respect to iodide ions, I^- .

Complete Table 2.1 to suggest volumes of reagents, compared to **experiment 1**, that could be used in a further experiment to confirm whether the student is correct.

You are not required to carry out the experiment.

Table 2.1

volume / cm ³			
FA 3	FA 4	FA 5	water

[1]

[Total: 12]

3 Determination of the concentration of sodium hydroxide in a mixture of sodium hydroxide and sodium carbonate

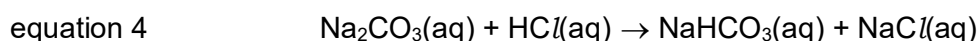
FA 6 is $0.100 \text{ mol dm}^{-3}$ hydrochloric acid, HCl .

FA 7 is a diluted aqueous solution containing a mixture of sodium hydroxide, NaOH , and sodium carbonate, Na_2CO_3 .

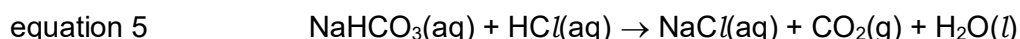
You are also provided with **thymol blue** and **screened methyl orange** as indicators.

Aqueous sodium hydroxide easily reacts with atmospheric carbon dioxide. This results in the sodium hydroxide being contaminated with sodium carbonate Na_2CO_3 .

When the mixture is titrated with hydrochloric acid using thymol blue as indicator, the reactions in equations 3 and 4 would have taken place when thymol blue changes colour.



If screened methyl orange is **subsequently** added as the indicator and the titration is **continued**, the NaHCO_3 produced undergoes further reaction with HCl , as shown in equation 5.



FA 7 was prepared by diluting 48.50 cm^3 of **FA 8**, a concentrated solution containing sodium hydroxide, NaOH , and sodium carbonate, Na_2CO_3 , to 1 dm^3 in a volumetric flask using deionised water.

You will perform a two-part titration using **FA 6** to determine the concentration of sodium hydroxide and sodium carbonate in **FA 7**.

(a) Titration of FA 7 against FA 6, using thymol blue

- step 1 Fill the burette with **FA 6**.
- step 2 Use a pipette to transfer 10.0 cm^3 of **FA 7** into a 250 cm^3 conical flask. Replace the cap over the bottle containing **FA 7** immediately and ensure that the bottle remains capped when you are not transferring **FA 7**.
- step 3 Add 5 or 6 drops of thymol blue indicator into the conical flask.
- step 4 Run **FA 6** from the burette into this flask until the solution turns from blue to pale yellow.
- step 5 Record your titration results for the **first end-point** in Table 3.1. **Keep the solution for Step 6.**

Continued titration of FA 7 against FA 6, using screened methyl orange

- step 6 Add 5 or 6 drops of screened methyl orange indicator into the conical flask from step 5.
- step 7 Continue to run **FA 6** from the burette into this flask until the solution turns grey.
- step 8 Record your titration results for this **second end-point** in Table 3.1.
- step 9 Calculate and record in Table 3.2
- volume of **FA 6**, V_1 , required to reach the first end-point
 - total volume of **FA 6**, V_2 , required to reach the second end-point
- step 10 Repeat steps 1 to 8 as necessary until consistent results are obtained for steps **5** and **8**.

Table 3.1

titration	1	2			
final burette reading at second end-point / cm ³					
final burette reading at first end-point / cm ³					
initial burette reading / cm ³					

Table 3.2

titration	1	2			
volume of FA 6 , V_1 , required to reach first end-point / cm ³					
total volume of FA 6 , V_2 , required to reach second end-point / cm ³					

[4]

- (i) From your titrations, obtain a suitable volume of the following, to be used in your calculations. Show clearly how you obtained these volumes.

- total volume of **FA 6**, V_2 , required to reach the second end-point

$$V_2 = \dots\dots\dots \text{cm}^3$$

- volume of **FA 6**, V_1 , required to reach the first end-point.

$$V_1 = \dots\dots\dots \text{cm}^3$$

[1]

- (ii) Using your values from **(a)(i)**, obtain a suitable volume of **FA 6** required for reaction in equation 3, to be used in your calculations.

$$\text{volume of FA 6 required} = \dots\dots\dots \text{cm}^3$$

[1]

- (b) (i) Using relevant answers in **3(a)** and equations 3 to 5, calculate the concentration in mol dm^{-3} , of sodium carbonate, Na_2CO_3 , and sodium hydroxide, NaOH , present in 10.0 cm^3 of **FA 7**.

$$\text{concentration of Na}_2\text{CO}_3 \text{ in FA 7} = \dots\dots\dots$$

$$\text{concentration of NaOH in FA 7} = \dots\dots\dots$$

[3]

- (ii) Hence, calculate the concentration of NaOH in mol dm^{-3} , in the concentrated solution of **FA 8**.

$$\text{concentration of NaOH in FA 8} = \dots\dots\dots$$

[3]

- (c) In step 2 of the titration, instructions were given to ensure that the bottle of **FA 7** remains capped as much as possible.

With the aid of an appropriate equation, explain why this is necessary.

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

- (d) State and explain how the volume of acid required for the first end-point will change if $\text{CH}_3\text{CO}_2\text{H}(\text{aq})$ is used instead of $\text{HCl}(\text{aq})$.

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

- (e) Suggest how the experiment can be modified to determine the percentage composition of each component in the **FA 7** mixture without using an indicator.

Briefly describe how the method would be carried out, including what apparatus you would use in addition to that used in (a) .

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..... [2]

[Total: 17]

4 Planning

When solid sodium hydrogencarbonate, NaHCO_3 , is dissolved in deionised water, heat is absorbed.

The maximum temperature change occurring during the dissolution may be determined graphically.

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, $\Delta H_{\text{solution}}$, 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, $\Delta H_{\text{solution}}$ for sodium hydrogencarbonate.

(a) The enthalpy change of solution is found to be approximately $+18.0 \text{ kJ mol}^{-1}$.

Calculate a suitable mass of sodium hydrogencarbonate for your experiment, stating any assumptions made clearly.

Assume that 4.18 J of heat energy raises the temperature of 1.0 cm^3 of the mixture by $1.0 \text{ }^\circ\text{C}$.
[Ar: Na = 23.0; H = 1.0; C = 12.0; O = 16.0]

[2]

- (b) Plan an investigation to determine the maximum temperature change, ΔT_{max} , when sodium hydrogencarbonate is dissolved in deionised water using a **graphical method**.

Measurements should be taken:

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

You may assume that you are provided with:

- deionised water,
- 50 g of sodium hydrogencarbonate,
- 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 to allow a suitable temperature-time graph to be drawn,
- how you would ensure that an **accurate** and **reliable** value of ΔT_{max} is obtained.

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- (c) (i) Sketch, on Figure 4.1, the graph you would expect to obtain using the measurements you planned to make in **4(b)**.

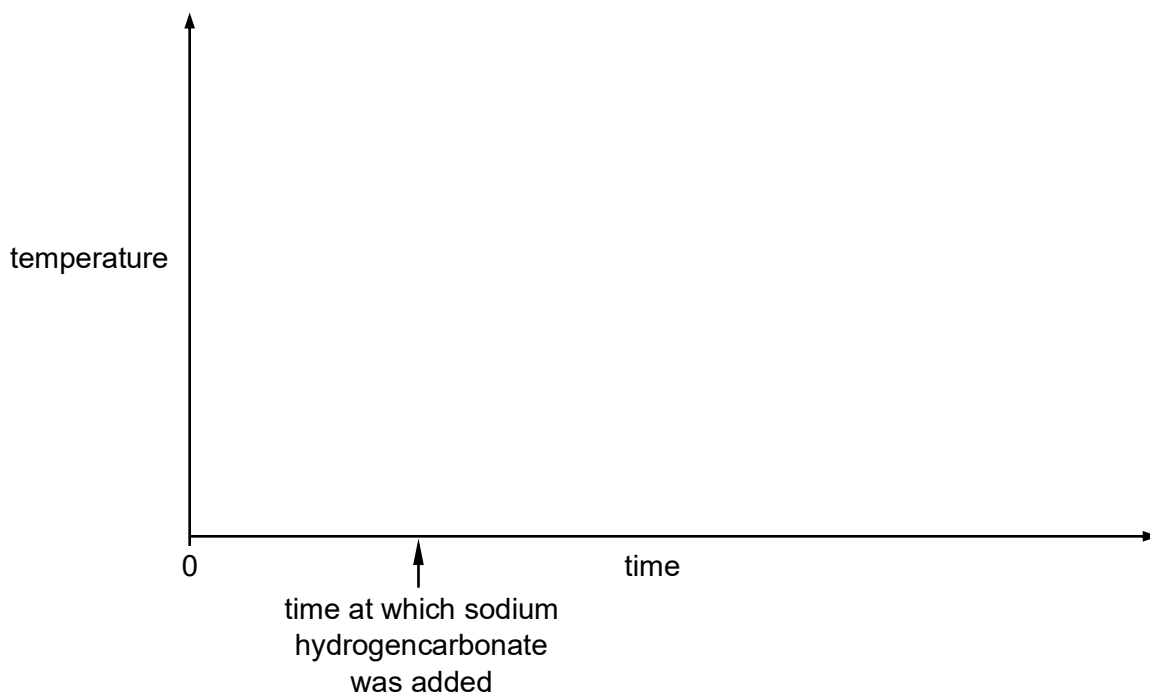


Figure 4.1

[1]

- (ii) Explain how the maximum temperature change, ΔT_{max} , can be determined. You may find it useful to show how this might be done on your graph in **4(c)(i)**.

.....

.....

.....

..... [1]

[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) 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

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) • give 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 $\text{NaOH}(\text{aq})$