



EUNOIA JUNIOR COLLEGE
JC2 Preliminary Examination 2025
General Certificate of Education Advanced Level
Higher 2

CANDIDATE
NAME

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CIVICS
GROUP

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INDEX
NUMBER

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CHEMISTRY

Paper 4 Practical

9729/04

21 August 2025

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.

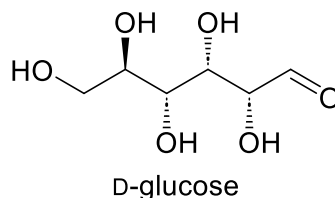
Shift	
Laboratory	
For Examiner's Use	
1	/ 5
2	/11
3	/17
4	/ 9
5	/13
Total	/55

This document consists of **20** printed pages.

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

1 Investigation of redox reactions involving D-glucose

D-Glucose is a sugar with molecular formula $C_6H_{12}O_6$, which can react directly or indirectly with potassium manganate(VII), $KMnO_4$.



- (a) **FA 1** is a solution of potassium manganate(VII), $KMnO_4$.
FA 2 is a 1.0 mol dm^{-3} sulfuric acid solution, H_2SO_4 .

You are also provided with a solution of D-glucose and bench reagents.

Perform the tests described in Table 1.1 and record your observations in the table.

Table 1.1

test		observations
(i)	<p>Add 1 cm depth of FA 1 to a test-tube. Add an equal volume of aqueous sodium hydroxide.</p> <p>Add 1 drop of glucose solution and shake thoroughly.</p> <p>Allow to stand for 10 minutes, with occasional shaking. Continue with the remaining parts of Question 1.</p>	
(ii)	<p>Add 1 cm depth of FA 1 to a boiling tube. Add 2 cm depth of FA 2.</p> <p>Add 1 cm depth of glucose solution and warm gently. Shake well to mix.</p>	

[2]

(b) Manganese species exist in ions of different oxidation states and colours.

Suggest the identity of the **final** manganese-containing species in (a)(i) and in (a)(ii).

final manganese-containing species in (a)(i).....

final manganese-containing species in (a)(ii).....

[1]

(c) In (a)(i), D-glucose, $C_6H_{12}O_6$, reacts with $KMnO_4$ in alkaline medium to give D-gluconate, $C_6H_{11}O_7^-$.

(i) Name the type of reaction that D-glucose undergoes in (a).

..... [1]

(ii) Draw the structure of the D-gluconate ion.

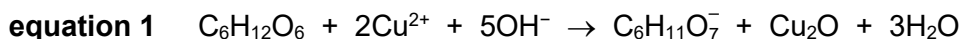
[1]

[Total: 5]

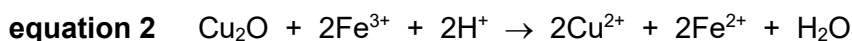
2 Determination of mass of D-glucose in a sample

The Bertrand method is a classical redox titration technique used to determine the amount of reducing sugars, such as D-glucose.

In this method, a sample of D-glucose, $C_6H_{12}O_6$, is reacted with excess alkaline copper(II) solution, Cu^{2+} , to form insoluble copper(I) oxide, Cu_2O .

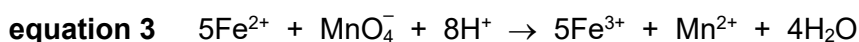


The Cu_2O is filtered and dissolved in 100 cm³ acidic iron(III) solution, Fe^{3+} .



The resulting solution is then diluted to 1 dm³. The diluted solution is labelled **FA 3**.

The amount of Fe^{2+} present in **FA 3** is then determined by titration with potassium manganate(VII), $KMnO_4$, in acidic medium. The end-point of the titration occurs when the presence of unreacted MnO_4^- causes the colour of the solution to become pale pink.



You are to determine the amount of Fe^{2+} present in **FA 3** and hence determine the mass of D-glucose in the sample.

FA 1 is 0.0200 mol dm⁻³ potassium manganate(VII), $KMnO_4$.

FA 2 is 1.0 mol dm⁻³ sulfuric acid solution, H_2SO_4 .

(a) (i) Procedure

1. Fill the burette with **FA 1**.
2. Pipette 25.0 cm³ of **FA 3** into a clean 250 cm³ conical flask.
3. Use a measuring cylinder to add 10.0 cm³ of **FA 2** to the conical flask.
4. Run **FA 1** from the burette into the conical flask. The end-point is reached when the **first permanent** trace of pale pink colour is seen.
5. Record your titration results, to an appropriate level of precision, in Table 2.1.
6. Repeat points 2 to 5 until consistent titre values are obtained.

Table 2.1

final burette reading / cm ³					
initial burette reading / cm ³					
volume of FA 1 used / cm ³					

[2]

- (ii) From your titration results, obtain a suitable volume of **FA 1** to be used in your calculations. Show clearly how you obtained this volume.

volume of **FA 1** = cm³ [3]

- (b) (i) Calculate the amount of Fe²⁺ in 1 dm³ of **FA 3**.

amount of Fe²⁺ in 1 dm³ of **FA 3** = [3]

- (ii) Calculate the mass of D-glucose, C₆H₁₂O₆, in the sample.
[A_r: H, 1.0; C, 12.0; O, 16.0]

mass of glucose in sample = [2]

- (c) A student repeated the procedure in (a) and obtained an average titre value of 19.50 cm³.

The errors (uncertainties) associated with **each reading** using pipette and burette are ± 0.10 cm³ and ± 0.05 cm³ respectively.

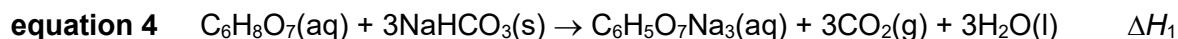
Calculate the maximum total percentage error (uncertainty) of this average titre volume.

[1]

[Total: 11]

3 Determination of the enthalpy change when citric acid reacts with sodium hydrogencarbonate

Citric acid, $\text{C}_6\text{H}_8\text{O}_7$, is found in citrus fruit such as lemons and limes. It is a triprotic (tribasic) acid – one mole of citric acid reacts with three moles of sodium hydrogencarbonate.



FA 4 is $0.080 \text{ mol dm}^{-3}$ citric acid, $\text{C}_6\text{H}_8\text{O}_7$.

FA 5 is solid sodium hydrogencarbonate, NaHCO_3 .

- (a) Calculate the minimum mass of sodium hydrogencarbonate that will react completely with the citric acid in 50.0 cm^3 of **FA 4**.
[A_r: Na, 23.0; H, 1.0; C, 12.0; O, 16.0]

minimum mass of NaHCO_3 = [1]

(b) Determination of the molar enthalpy change of reaction, ΔH_1

In this experiment, you will measure the temperature of the contents of a polystyrene cup at timed intervals, both before and after an excess of **FA 5** is added. You will analyse your results graphically to obtain an accurate value for the temperature change caused by the reaction.

You will use this value to calculate the heat change, q , for the experiment and hence determine a value for the molar enthalpy change of the reaction, ΔH_1 .

In the space provided on page 7, prepare a table in which to record for your experiment:

- all values of temperature, T , to an appropriate level of precision
- all values of time, t , recorded to the nearest 0.5 min.

It is important that you measure each temperature at the specified time.

Procedure

1. Measure 50.0 cm³ of **FA 4** using a 50.0 cm³ measuring cylinder.
2. Place one polystyrene cup inside a glass beaker.
3. Transfer 50.00 cm³ of **FA 4** into the polystyrene cup.
4. Carefully stir the **FA 4** in the polystyrene cup with the thermometer. Read and record the temperature, T . Start the stopwatch ($t = 0.0$ min). The stopwatch must be left to run for the rest of the experiment.
5. Continue to stir **FA 4**. Read and record T every 0.5 minute for 1.5 minutes.
6. At exactly 2.0 minutes, transfer all the solid **FA 5** (an excess) to the polystyrene cup. Stir the mixture thoroughly but do not read T .
7. Continue to stir the mixture. Read and record T at $t = 2.5$ min and every 0.5 min until the temperature reaches a minimum, and then every minute for a further 4 minutes.

(i) Results

[3]

- (ii) Plot a graph of the temperature on the y-axis, against time, t , on the x-axis on the grid in Fig. 3.1.

Draw a best-fit straight line taking into account all of the points before $t = 2.0$ min.

Draw another best-fit straight line taking into account all of the points after the temperature of the mixture has started to rise steadily.

Extrapolate (extend) both lines to $t = 2.0$ min.

[3]

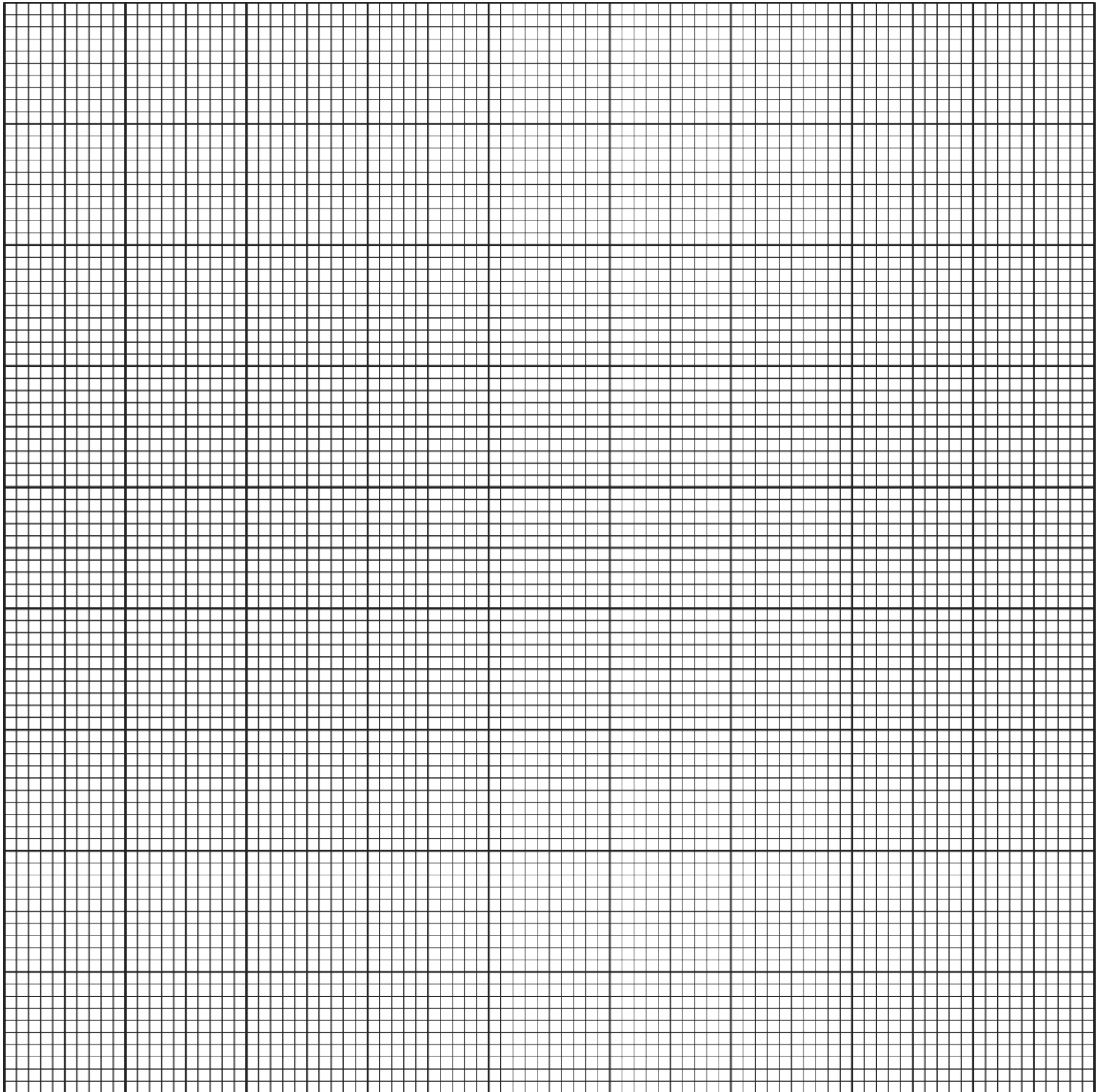


Fig. 3.1

- (iii) From your graph, read the minimum temperature, T_{\min} , and the maximum temperature, T_{\max} , at $t = 2.0$ min. Record these values in the spaces provided.

Deduce the temperature change, ΔT , at $t = 2.0$ min.

$T_{\min} =$

$T_{\max} =$

$\Delta T =$

[1]

- (iv) Calculate the heat change, q , for your experiment using the value you calculated in (b)(iii).

Assume that the specific heat capacity of the reaction mixture is $4.18 \text{ J g}^{-1} \text{ K}^{-1}$, and that the density of the solution is 1.00 g cm^{-3} .

$q =$ [1]

- (v) Determine the molar enthalpy change, ΔH_1 , for the reaction in equation 4. The sodium hydrogencarbonate is in excess.

Include the sign of ΔH_1 in your answer.

$\Delta H_1 =$ [5]

- (c) (i) The maximum temperature change, ΔT_{\max} , can also be determined by direct measurement of the initial temperature and the lowest temperature reached only.

Explain why the graphical method is likely to give a more accurate value for ΔT_{\max} than the direct measurement method.

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

- (ii) What would be the expected change in temperature obtained in (b)(iii) if the volume of citric acid used was halved? Explain your answer.

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

[Total: 17]

4 Qualitative Analysis

S is a mixture of two solids: **FA 6**, which is soluble in water and **FA 7**, which is insoluble in water. Each of **FA 6** and **FA 7** contains one cation and one anion.

S does not contain halide ions.

- (a) Carry out the following tests. Test and identify any gases evolved. Carefully record your observations in Table 4.1.

If there are no observable changes, write **no observable change**.

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

Table 4.1

	test	observations
1	Place all of solid S , into a boiling tube. Add 15 cm ³ of deionised water and shake for 2 minutes. Filter the mixture, collecting the filtrate in a test-tube. Keep the filtrate for tests 2 and 3. Wash the residue in the filter paper, with a little deionised water. Discard the washings. Keep the residue for test 4.	
2	Add 1 cm depth of the filtrate to a test tube. Add aqueous ammonia.	
3	Add 1 cm depth of the filtrate to a boiling tube. Add aqueous sodium hydroxide. Warm the mixture carefully for 2 minutes. Add a small piece of aluminium foil and warm the mixture carefully.	

4	<p>Using a spatula, transfer some of the solid residue from the filter paper into a test-tube.</p> <p>Add 2 cm depth of FA 2 (H_2SO_4) to the same tube.</p> <p>Keep this solution for test 5.</p>	
5	<p>To the resultant solution from test 4, add an equal volume of deionised water and shake the test-tube. Divide the liquid into two equal portions.</p> <p>To the first portion, add aqueous sodium hydroxide.</p> <p>To the second portion, add aqueous ammonia.</p>	

[4]

- (b) Identify the ions in **FA 6** and **FA 7** respectively and state the evidence by completing Table 4.2.

Table 4.2

		evidence
(i)	cation in FA 6	
(ii)	cation in FA 7	
(iii)	anion in FA 7	

[3]

- (c) Using your observation in Test 3, suggest the possible identities of the anion in **FA 6**. Hence describe a test to confirm the identity of the anion. You do not need to carry out this test.

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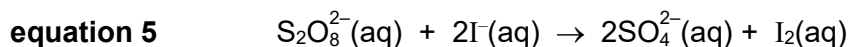
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..... [2]

[Total: 9]

5 Planning

Iodide ions, I^- , react with peroxodisulfate ions, $\text{S}_2\text{O}_8^{2-}$, as shown in equation 5.



If $\text{I}^-(\text{aq})$ is used in large excess in the reaction, the simplified rate equation becomes

$$\text{rate} = k'[\text{S}_2\text{O}_8^{2-}]^a \quad \text{where } k' = k[\text{I}^-]$$

The order of reaction with respect to peroxodisulfate ions can be determined experimentally using the continuous method. Since iodine (I_2) is formed during the reaction, the concentration of iodine can be measured continuously at various time intervals by sampling, quenching using cold water, followed by titration with aqueous sodium thiosulfate.

(a) You will prepare a reaction mixture consisting of

- 70 cm^3 of 0.400 mol dm^{-3} aqueous potassium iodide, KI
- 30 cm^3 of 0.010 mol dm^{-3} aqueous peroxodisulfate ions, $\text{S}_2\text{O}_8^{2-}$

You are also provided with

- 0.003 mol dm^{-3} sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$
- starch
- the equipment normally found in a school or college laboratory.

Plan an investigation to determine the order of reaction with respect to peroxodisulfate, $\text{S}_2\text{O}_8^{2-}$, using the continuous method.

In your plan you should include brief details of:

- the quantities of all reagents you would use,
- the apparatus and the procedure you would follow,
- the measurements you would take to allow for a suitable volume-time graph to be drawn from time, $t = 0$ min to $t = 20$ min.

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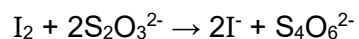
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- (b) (i) V_{\max} represents the volume of sodium thiosulfate required to react with the iodine produced when the reaction as shown by equation 5 has completed, in a 10.0 cm^3 aliquot of the reaction mixture.



Show that V_{\max} is 20.00 cm^3 .

[2]

- (ii) Using information from (b) (i), sketch on Fig. 5.1 an appropriately labelled graph to show that the reaction is first order with respect to peroxodisulfate ions.

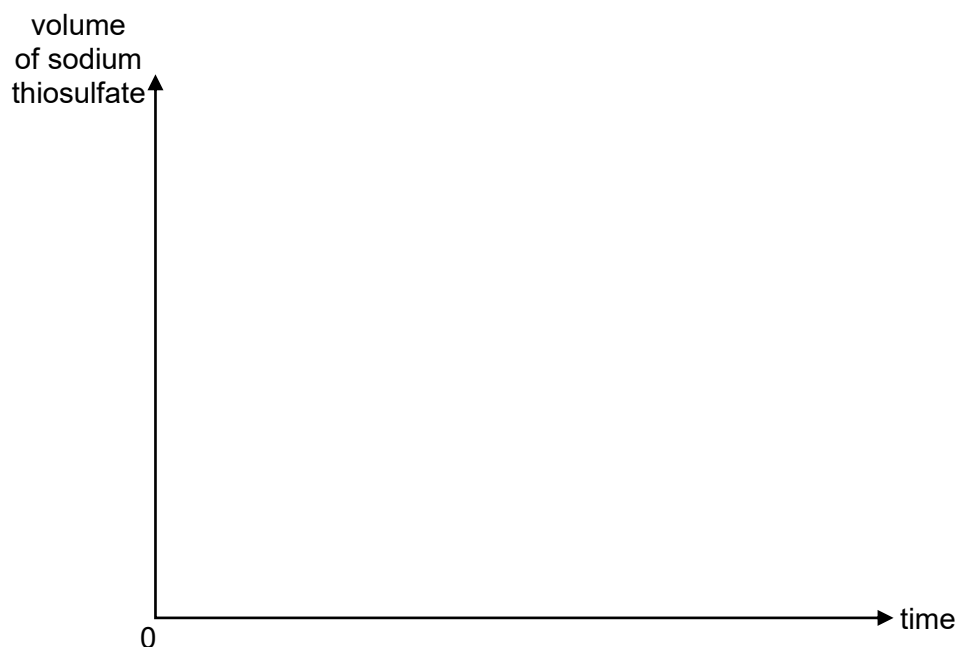


Fig. 5.1

[2]

(c) The reaction between peroxodisulfate ions and iodide ions as shown in equation 5 is slow. The reaction can be sped up by the addition of iron(II) catalyst, Fe^{2+} catalyst.

(i) Suggest why the reaction between peroxodisulfate ions and iodide ions is slow at room temperature.

.....

 [1]

(ii) The experimental procedure in (a) is modified to determine the order of reaction with respect to the iron(II) catalyst in the reaction between peroxodisulfate and iodide ions.

Two additional experiments were conducted with iron(II) catalyst added at the beginning.

You are provided with 50 cm³ of 0.01 mol dm⁻³ iron(II) nitrate solution, $\text{Fe}(\text{NO}_3)_2$.

- Complete Table 5.1 with suitable volumes of reagents used.
- Describe how you would make use of the data collected to determine the order of reaction with respect to the iron(II) catalyst.

Table 5.1

expt	volume of $\text{S}_2\text{O}_8^{2-}$ / cm ³	volume of I^- / cm ³	volume of H_2O / cm ³	volume of Fe^{2+} / cm ³
1	30	70		
2	30	70		

.....

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.....

.....

.....

.....

..... [3]

[Total: 13]

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