Past-paper walk-through

Some reactions of the halide ions ▪ 11.3

eXercise

Questions in this set

- 9701/11 N25 Q21 ▪ 1 mark
- 9701/12 N25 Q22 ▪ 1 mark
- 9701/14 N25 Q21 ▪ 1 mark
- 9701/31 N25 Q3 ▪ 15 marks
- 9701/34 N25 Q3 ▪ 15 marks
- 9701/34 J25 Q3 ▪ 14 marks

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 21

9701/11 N25 ▪ Q21 ▪ 1 mark

21 Equation 1 and equation 2 show two different reactions of halide ion Q^- with concentrated sulfuric acid.

equation 1 $H_2SO_4 + Q^- \rightarrow HSO_4^- + HQ$

equation 2 $H_2SO_4 + 2Q^- + 2H^+ \rightarrow SO_2 + Q_2 + 2H_2O$

What is Q?

A Cl^- or Br^- **B** Br^- or I^- **C** Cl^- only **D** I^- only

Solution 21

Answer: **B**

Why

- Every halide gives the simple acid–base reaction of equation 1.
- Equation 2 needs the halide to *reduce* sulfur from $+6$ to $+4$, and chloride is too weak a reducing agent for that.
- Bromide and iodide are both strong enough, so Q is Br^- or I^-.

Question 22

9701/12 N25 ▪ Q22 ▪ 1 mark

22 X and Y are sodium salts of Group 17 elements.

When X reacts with concentrated sulfuric acid, hydrogen sulfide, H_2S, is produced.

When Y reacts with concentrated sulfuric acid, there is no change in the oxidation number of the sulfur.

Which statement is correct?

A Aqueous X reduces aqueous bromine.

B Aqueous Y reacts with aqueous silver nitrate to give a precipitate which is insoluble in concentrated aqueous ammonia.

C X and Y react separately with concentrated sulfuric acid to produce halogens.

Question 22

D When X reacts with concentrated sulfuric acid, six halide ions are needed to reduce one sulfur atom to H_2S.

Solution 22

Answer: **A**

Why

- H_2S means sulfur has been reduced all the way from $+6$ to -2, and only iodide can do that – X is the iodide.
- Y causes no change in sulfur's oxidation number, so Y is the chloride.
- Iodide is a strong enough reducing agent to reduce bromine to bromide, so A is the correct statement.

Question 21

9701/14 N25 ▪ Q21 ▪ 1 mark

21 X, Y and Z are three aqueous solutions. Equal volumes of pairs of the solutions are mixed and observations noted.

X mixed with Y shows no reaction.

X mixed with Z shows an immediate reaction.

Z mixed with Y shows no reaction.

What are X, Y and Z?

	X	Y	Z
A	Br_2(aq)	I_2(aq)	HBr(aq)
B	Cl_2(aq)	I_2(aq)	HBr(aq)
C	HCl(aq)	HI(aq)	Br_2(aq)

Question 21

D	HCl(aq)	Br_2(aq)	HBr(aq)

Solution 21

Answer: **B**

Why

- A halogen reacts with a halide only if the halogen is *higher* in the group.
- Chlorine is above bromine, so Cl_2 reacts at once with HBr – that is X with Z.
- Two halogens do not react with each other, and bromide cannot reduce iodine, so both other pairings give nothing.

Question 3

9701/31 N25 ▪ Q3 ▪ 15 marks

3 **(a)** A bottle labelled **FA 5** is thought to contain hydrated zinc sulfate. It would therefore contain zinc ions and sulfate ions as well as water of crystallisation.

(i) Devise and carry out tests to investigate whether zinc ions, sulfate ions and water of crystallisation are present.

Record the tests you carry out and the observations you see in the space provided.

Question 3

[5]

(ii) Use your observations in **(a)(i)** to complete Table 3.1 to show whether each species is present in **FA 5**.

Use a tick (✓) if the species is present.

Use a cross (✗) if the species is **not** present.

Table 3.1

Zn^{2+}	
SO_4^{2-}	
H_2O	

[1]

(b) You are provided with solid **FA 6**.

Question 3

Question 3

(i) Heat a few crystals of **FA 6** in a hard-glass test-tube until no further gas is evolved. Record all your observations.

Leave the test-tube until it is cool.

Keep the cooled residue for use in (b)(ii).

Question 3

(ii) To the cooled residue from **(b)(i)**, add approximately 3 cm depth of distilled water and stir. Filter the solution formed into a test-tube.

Question 3

(c) You are provided with aqueous solutions **FA 7** and **FA 8** and with solid **FA 9**.

FA 7 is an aqueous solution of **FA 6**.
FA 7, **FA 8** and **FA 9** contain compounds which all have one metal that is the same but which may be in different oxidation states.

(i) Carry out the following tests on **FA 7**, **FA 8** and **FA 9** and record your observations in Table 3.2. For each test use a 1 cm depth of a solution or a spatula measure of solid.

Table 3.2

test	*observations*		
	FA 7	**FA 8**	**FA 9**
Test 1 Add hydrogen			

Question 3

peroxide.

Question 3

Test 2 Add aqueous sodium hydroxide, then			
leave to stand.			
Test 3 Add aqueous iron(II) sulfate.			

Question 3

Question 3

[1]

(ii) Suggest the identity of the metal in **FA 6**/**FA 7**, **FA 8** and **FA 9**.

The metal is ..... . [1]

(iii) Complete Table 3.3 to suggest the oxidation state of the metal in **FA 6**/**FA 7** and **FA 8**.

Table 3.3

	FA 6/**FA 7**	**FA 8**
oxidation state		

[1]

[Total: 15]

Qualitative analysis notes

Question 3

Question 3

1 Reactions of 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)	no ppt. ammonia produced on warming	–
barium, Ba^{2+}(aq)	faint white ppt. is observed unless $[Ba^{2+}(aq)]$ is very low	no ppt.
calcium, Ca^{2+}(aq)	white ppt. unless $[Ca^{2+}(aq)]$ is very low	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	pale blue ppt. soluble in excess giving dark blue solution

Question 3

giving dark blue solution

Question 3

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

2 Reactions of anions

anion	reaction
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, $Cl^-(aq)$	gives white ppt. with $Ag^+(aq)$ (soluble in $NH_3(aq)$)

Question 3

chloride, Cl^-(aq)	gives white ppt. with Ag^+(aq) (soluble in NH_3(aq))
bromide, Br^-(aq)	gives cream / off-white ppt. with Ag^+(aq) (partially soluble in NH_3(aq))
iodide, I^-(aq)	gives pale yellow ppt. with Ag^+(aq) (insoluble in NH_3(aq))
nitrate, NO_3^-(aq)	NH_3 liberated on heating with OH^-(aq) and Al foil
nitrite, NO_2^-(aq)	NH_3 liberated on heating with OH^-(aq) and Al foil; decolourises acidified aqueous $KMnO_4$
sulfate, SO_4^{2-}(aq)	gives white ppt. with Ba^{2+}(aq) (insoluble in excess dilute strong acids); gives white ppt. with high [Ca^{2+}(aq)]
sulfite, SO_3^{2-}(aq)	gives white ppt. with Ba^{2+}(aq) (soluble in excess dilute strong acids); decolourises acidified aqueous $KMnO_4$
thiosulfate, $S_2O_3^{2-}$(aq)	gives off-white / pale yellow ppt. slowly with H^+

3 Tests for gases

gas	test and test result

Question 3

ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	gives a white ppt. with limewater
hydrogen, H_2	‘pops’ with a lighted splint
oxygen, O_2	relights a glowing splint

Solution 3

(a)(i) Mark scheme

- M1 Heat (solid FA 5)
- AND
- observe condensation, droplets, steam, water vapour M2
- Make an aqueous solution of FA 5 / dissolve in water to use for tests M3
- (To portion of the solution) add aqueous NH3
- AND
- white ppt AND insoluble in excess NH3 M4
- (To portion of the solution) add aqueous barium chloride or barium nitrate

Solution 3

- AND
- white precipitate **M5**
- to distinguish sulfate / sulfite
- (white precipitate from M4) insoluble in hydrochloric OR nitric acid
- OR
- KMnO4 is not decolourised / remains purple (added after M4 or directly to FA 5 (aq))
- 5

Solution 3

(a)(ii) Mark scheme

- Zn^{2+}
- X
- SO_4^{2-}
-
- H_2O
-
- 1

Solution 3

(b)(i) Mark scheme

- ▪
- (FA 6) starting colour purple
- ▪
- solid jumps / moves around
- ▪
- black residue
- ▪
- test with glowing splint

Solution 3

- ▪
- splint relights / glows more brightly
- 2

Solution 3

(b)(ii)

Mark scheme

- (dark) Green
- 1
- 9701/31
- October/November 2025

Solution 3

(c)(i) Mark scheme

- 'No change' 2 correct = *, 3 correct = **
- 2* = 1 mark
- Max mark = 4
- test
- observations
- FA 7
- FA 8
- FA 9

Solution 3

- Test 1
- Add
- hydrogen peroxide
- Bubbles/ effervescence *
- Purple / FA 7 (solution) to
- colourless (solution) *
- (Gas / oxygen) relights
- glowing splint *
- No change
- Bubbles / effervescence *

Solution 3

- (Gas/ oxygen) relights
- glowing splint *
- Test 2
- Add
- sodium hydroxide,
- then
- Off-white ppt*
- No change
- leave to stand
- brown ppt on standing*

Solution 3

- Test 3
- Add aqueous
- iron(II) sulfate
- Turns colourless / yellow
- OR colourless / yellow
- solution formed*
- No change
- 4

Solution 3

(c)(ii)

Mark scheme

- manganese / Mn
- 1
- 9701/31
- October/November 2025

Solution 3

(c)(iii) Mark scheme

- FA 6 / FA 7
- FA 8
- oxidation
- state
- (+)7
- (+)2
- 1

Question 3

9701/34 N25 ▪ Q3 ▪ 15 marks

3 **(a)** **(i)** To a 1 cm depth of **FB 4** in a boiling tube, slowly add a 1 cm depth of dilute nitric acid. Stir gently until the reaction is complete. Use this solution for your tests.
Select reagents to identify which sodium halide is present.
Record details of the reagents used and your observations.
Identify the sodium halide that is present as an impurity in **FB 4**.

Question 3

[2]

(ii) Suggest why it is necessary to add the nitric acid to **FB 4** before carrying out your tests in **(a)(i)**.

Question 3

(b) **FB 7** contains a metal cation which is listed in the Qualitative analysis notes.

(i) Place half the sample of **FB 7** in a hard-glass test-tube. Heat gently at first and then more strongly.
Record your observations.

Question 3

(ii) Use the 25 cm^3 measuring cylinder to measure 20 cm^3 of **FB 1**.
Place the remaining sample of **FB 7** in a boiling tube and add portions of **FB 1** from the measuring cylinder until all the **FB 7** has reacted. Stir until the reaction is complete.
Record your observations.

Keep this solution for use in (b)(iii).

Question 3

(iii) Carry out the following tests. For each test use a 1 cm depth of the solution from **(b)(ii)** in a test-tube.
Record your observations in Table 3.1.
Identify the metal ion present in **FB 7**.

Table 3.1

test	*observations*
Test 1 Add aqueous sodium hydroxide.	
Test 2 Add aqueous ammonia.	

Question 3

Question 3

Test 3 Add a piece of aluminium foil.	

Question 3

[4]

(c) **FB 8** is an acidified aqueous solution containing a metal cation which is listed in the Qualitative analysis notes.

(i) Carry out the following tests. For each test use a 1 cm depth of **FB 8** in a test-tube.
Record your observations in Table 3.2.
Identify the metal ion present in **FB 8**.

Table 3.2

test	*observations*
Test 1 Add aqueous sodium hydroxide.	
Test 2	

Question 3

Test 2

Question 3

Add a 1 cm depth of acidified aqueous potassium manganate(VII).	

Question 3

[3]

(ii) State the type of reaction between the metal ion in **FB 8** and acidified aqueous potassium manganate(VII).
Explain how your observations support your answer.

Question 3

[Total: 15]

Qualitative analysis notes

1 Reactions of 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)	no ppt. ammonia produced on warming	–
barium, Ba^{2+}(aq)	faint white ppt. is observed unless [Ba^{2+}(aq)] is very low	no ppt.
calcium, Ca^{2+}(aq)	white ppt. unless [Ca^{2+}(aq)] is very low	no ppt.

Question 3

chromium(III), $Cr^{3+}(aq)$	grey-green ppt. soluble in excess	grey-green ppt. insoluble in excess

Question 3

	giving dark green solution	
copper(II), Cu^{2+}(aq)	pale blue ppt. insoluble in excess	pale 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

2 Reactions of anions

Question 3

anion	reaction
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, Cl^-(aq)	gives white ppt. with Ag^+(aq) (soluble in NH_3(aq))
bromide, Br^-(aq)	gives cream / off-white ppt. with Ag^+(aq) (partially soluble in NH_3(aq))
iodide, I^-(aq)	gives pale yellow ppt. with Ag^+(aq) (insoluble in NH_3(aq))
nitrate, NO_3^-(aq)	NH_3 liberated on heating with OH^-(aq) and Al foil
nitrite, NO_2^-(aq)	NH_3 liberated on heating with OH^-(aq) and Al foil; decolourises acidified aqueous $KMnO_4$
sulfate, SO_4^{2-}(aq)	gives white ppt. with Ba^{2+}(aq) (insoluble in excess dilute strong acids); gives white ppt. with high [Ca^{2+}(aq)]
sulfite, SO_3^{2-}(aq)	gives white ppt. with Ba^{2+}(aq) (soluble in excess dilute strong acids); decolourises acidified aqueous $KMnO_4$
thiosulfate, $S_2O_3^{2-}$(aq)	gives off-white / pale yellow ppt. slowly with H^+

Question 3

3 Tests for gases

gas	test and test result
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	gives a white ppt. with limewater
hydrogen, H_2	‘pops’ with a lighted splint
oxygen, O_2	relights a glowing splint

Solution 3

(a)(i) Mark scheme

- ▪
- selects (aqueous) silver nitrate and (aqueous) ammonia *
- ▪
- white ppt *
- ▪
- soluble in (aqueous) ammonia *
- ▪
- NaCl *

Solution 3

- 2 * = 1 mark
- 2

Solution 3

(a)(ii)

Mark scheme

- (The acid) removes / reacts with the hydrogencarbonate ions OR silver ions react with hydrogencarbonate ions
- 1

Solution 3

(b)(i) Mark scheme

- ▪
- green (at start) *
- ▪
- turns to a black powder / solid *
- ▪
- powder very fluid / moves around the test-tube *
- ▪
- condensation (on walls of test-tube) *

Solution 3

- 2 * = 1 mark
- 2

Solution 3

(b)(ii) Mark scheme

- ▪
- forms green-blue solution *
- ▪
- effervescence *
- ▪
- vigorous reaction *
- ▪
- attempts to test with limewater *

Solution 3

- ▪
- gas / carbon dioxide gives white precipitate / solid with limewater *
- 2 * = 1 mark
- 2
- 9701/34
- October/November 2025
- Question Answer

Solution 3

(b)(iii) Mark scheme

- Test 1
- Add NaOH(aq)
- (pale) blue precipitate insoluble in excess *
- Test 2
- Add NH3(aq)
- (pale) blue precipitate *
- (precipitate dissolves forming) dark / deep blue solution in excess *
- Test 3

Solution 3

- Add aluminium
- foil
- effervescence / fizzing*
- (gas) pops with a lighted splint *
- pink-brown solid *
- turns colourless / pale blue solution formed *
- gets hotter *
- Metal ion in FB 7: Cu2+ *
- 2 * = 1 mark
- 4

Solution 3

(c)(i) Mark scheme

- Test 1
- Add NaOH(aq)
- green precipitate *
- insoluble in excess *
- (precipitate) turns brown (on surface) *
- Test 2
- Add acidified
- KMnO4

Solution 3

- purple to colourless / (pale) yellow solution
- OR KMnO4 decolourised*
- 2 * = 1 mark
- 2
- Metal ion in FB 8: Fe2+
- 1

Solution 3

(c)(ii)

Mark scheme

- Redox reaction
- AND change to colourless linked to reduction of manganate(VII) ions OR change to yellow colour linked to oxidation of
- Fe2+ or production of Fe3+.
- 1

Question 3

9701/34 J25 ▪ Q3 ▪ 14 marks

Qualitative analysis

For each test you should record all your observations in the spaces provided.
Examples of observations include:

- colour changes seen
- the formation of any precipitate and its solubility (where appropriate) in an excess of the reagent added
- the formation of any gas and its identification (where appropriate) by a suitable test.

You should record clearly at what stage in a test an observation is made.

Question 3

Where no change is observed, you should write 'no change'.
Where reagents are selected for use in a test, the name or correct formula of the element or compound must be given.
If any solution is warmed, a boiling tube must be used. If a solid is heated, a hard-glass test-tube must be used.
Rinse and reuse test-tubes and boiling tubes where possible.
No additional tests should be attempted.
(a)(i) Carry out the following tests and record your observations in Table 3.1. Three of the tests have been done for you. Use a 1 cm depth of solution in a test-tube for each test.
Table 3.1

test	*observations*		
	FB 6	**FB 7**	**FB 8**
Test 1 Add a small spatula measure of manganese(IV) oxide.	No change.	No change.	
Test 2 Add a 1 cm length of magnesium.			No change.
Test 3 Add a few drops of			

Question 3

[4]

(a)(ii) Use your observations in Table 3.1 to suggest a possible formula for each of FB 6, FB 7 and FB 8.

FB 6 FB 7 FB 8 **[2]**

Question 3

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)	no ppt. ammonia produced on warming	–
barium, Ba^{2+}(aq)	faint white ppt. is observed unless $[Ba^{2+}(aq)]$ is very low	no ppt.
calcium, Ca^{2+}(aq)	white ppt. unless $[Ca^{2+}(aq)]$ is very low	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	pale 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

Question 3

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

Question 3

test	*observations*		
	FB 6	**FB 7**	**FB 8**
Test 1 Add a small spatula measure of manganese(IV) oxide.	No change.	No change.	
Test 2 Add a 1 cm length of magnesium.			No change.
Test 3 Add a few drops of aqueous iron(II) sulfate.			

[4]

Question 3

anion	reaction
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, Cl^-(aq)	gives white ppt. with Ag^+(aq) (soluble in NH_3(aq))
bromide, Br^-(aq)	gives cream / off-white ppt. with Ag^+(aq) (partially soluble in NH_3(aq))
iodide, I^-(aq)	gives pale yellow ppt. with Ag^+(aq) (insoluble in NH_3(aq))
nitrate, NO_3^-(aq)	NH_3 liberated on heating with OH^-(aq) and Al foil
nitrite, NO_2^-(aq)	NH_3 liberated on heating with OH^-(aq) and Al foil; decolourises acidified aqueous $KMnO_4$
sulfate, SO_4^{2-}(aq)	gives white ppt. with Ba^{2+}(aq) (insoluble in excess dilute strong acids); gives white ppt. with high [Ca^{2+}(aq)]
sulfite, SO_3^{2-}(aq)	gives white ppt. with Ba^{2+}(aq) (soluble in excess dilute strong acids); decolourises acidified aqueous $KMnO_4$
thiosulfate, $S_2O_3^{2-}$(aq)	gives off-white / pale yellow ppt. slowly with H^+

3 Tests for gases