



EUNOIA JUNIOR COLLEGE
JC2 Preliminary Examination 2018
General Certificate of Education Advanced Level
Higher 2

CANDIDATE
NAME

--

CIVICS
GROUP

1	7	-		
---	---	---	--	--

INDEX
NUMBER

--	--

CHEMISTRY

Paper 4 Practical

9729/04

28 August 2018

2 hours 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.
Qualitative Analysis Notes are printed on pages 19 and 20.

Shift
Laboratory

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.

For Examiner's Use	
1	
2	
3	
4	
Total	

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

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

For
Examiner's
Use

1 Analysis of a solution containing both sodium hydroxide and sodium carbonate by Warder titration (double indicator method)

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

The Warder titration (double indicator method) can be used to analyse a mixture containing both sodium hydroxide and sodium carbonate.

FA 1 is $0.125 \text{ mol dm}^{-3}$ hydrochloric acid, HCl .

FA 2 is an aqueous solution containing sodium hydroxide, NaOH , and sodium carbonate, Na_2CO_3 .

(a) Titration of FA 2 against FA 1 using methyl orange or screened methyl orange indicator

In this titration, **FA 1** is run from the burette into the conical flask containing **FA 2** with methyl orange or screened methyl orange indicator.

The end-point is reached when the yellow colour changes to orange for methyl orange, or the green colour changes to grey for screened methyl orange.

- (i)**
1. Fill the burette with **FA 1**.
 2. Using a pipette, transfer 25.0 cm^3 of **FA 2** into a conical flask.
 3. Add a few drops of methyl orange or screened methyl orange indicator.
 4. Run **FA 1** from the burette into the conical flask until the colour of the solution changes.
 5. Record your titration results in the space provided below. Make certain that your recorded results show the precision of your working.
 6. Repeat points **1** to **5** as necessary until consistent results are obtained.

Results

[5]

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

For
Examiner's
Use

Volume of **FA 1** = [1]

(b) Titration of FA 2 against FA 1 using thymolphthalein indicator

When the titration in **(a)** was repeated using thymolphthalein as the indicator, 25.0 cm³ of **FA 2** required 23.35 cm³ of **FA 1**.

The following explains why different results were obtained using two different indicators.

- When **thymolphthalein** is used as the indicator, the following reactions would have taken place at the end-point of the titration.
 1. $\text{NaOH(aq)} + \text{HCl(aq)} \rightarrow \text{NaCl(aq)} + \text{H}_2\text{O(l)}$
 2. $\text{Na}_2\text{CO}_3\text{(aq)} + \text{HCl(aq)} \rightarrow \text{NaCl(aq)} + \text{NaHCO}_3\text{(aq)}$
 - When **methyl orange** is used as the indicator in **(a)**, the following reactions would have taken place at the end-point of the titration.
 1. $\text{NaOH(aq)} + \text{HCl(aq)} \rightarrow \text{NaCl(aq)} + \text{H}_2\text{O(l)}$
 2. $\text{Na}_2\text{CO}_3\text{(aq)} + \text{HCl(aq)} \rightarrow \text{NaCl(aq)} + \text{NaHCO}_3\text{(aq)}$
 3. $\text{NaHCO}_3\text{(aq)} + \text{HCl(aq)} \rightarrow \text{NaCl(aq)} + \text{CO}_2\text{(g)} + \text{H}_2\text{O(l)}$
- (i) Calculate the amount of hydrochloric acid present in the volume of **FA 1** calculated in **(a)(ii)**.

amount of HCl in volume in **(a)(ii)** = [1]

- (ii) Calculate the amount of hydrochloric acid in 23.35 cm³ of **FA 1**.

amount of HCl in 23.35 cm³ of **FA 1** = [1]

- (iii) Using your answer to (b)(i) and (b)(ii), calculate the amount of hydrochloric acid that reacts with the Na_2CO_3 in the titration using thymolphthalein indicator.

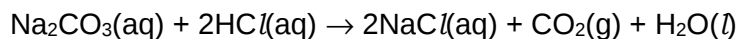
amount of HCl that react with Na_2CO_3 = [1]

- (iv) Hence, calculate the mass of sodium carbonate present in 25.0 cm^3 of **FA 2**.

[A_r : C, 12.0; O, 16.0; Na, 23.0]

mass of Na_2CO_3 in 25.0 cm^3 of **FA 2** = [1]

- (v) The **overall** equation for the reaction of Na_2CO_3 with HCl when methyl orange is used as indicator is given below.



Calculate the amount of HCl that reacted with the Na_2CO_3 in the above equation in 25.0 cm^3 of **FA 2**.

amount of HCl = [1]

- (vi) Use your answers to (b)(i) and (b)(v) to calculate the mass of sodium hydroxide in 25.0 cm^3 of **FA 2**.

[A_r : H, 1.0; O, 16.0; Na, 23.0]

mass of NaOH = [1]

- (vii) Calculate the percentage by mass of sodium carbonate in the mixture of sodium hydroxide and sodium carbonate in **FA 2**.

For
Examiner's
Use

percentage by mass of Na_2CO_3 in **FA 2** = [1]

- (c) The error (uncertainty) associated with **each reading** is given as follows:

50.00 cm³ burette: $\pm 0.05 \text{ cm}^3$

25.0 cm³ pipette: $\pm 0.04 \text{ cm}^3$

Using the above data, calculate the percentage error (uncertainty) when a

(I) 50.00 cm³ burette

(II) 25.0 cm³ pipette

is used to measure 25 cm³ of **FA 2** into the conical flask.

Hence state whether a 50.00 cm³ burette or 25.0 cm³ pipette will be more suitable to measure 25.0 cm³ of **FA 2** accurately.

.....

 [2]

[Total: 15]

2 To determine the percentage by mass of sodium hydrogencarbonate in the unknown sample based on gravimetric method

Sodium hydrogencarbonate decomposes on heating to give sodium carbonate, carbon dioxide and water vapour.



Sodium chloride on the other hand is unaffected by heat.

FA 3 is a mixture of anhydrous sodium hydrogencarbonate, NaHCO_3 , and sodium chloride, NaCl .

In this question, you will heat to decompose the sodium hydrogencarbonate in **FA 3** and determine the mass of carbon dioxide and water lost. The data will be used to determine

- the mass of NaHCO_3 in **FA 3**,
- the percentage composition by mass of NaHCO_3 in **FA 3**.

(a) Thermal decomposition of NaHCO_3

In this experiment, solid **FA 3** is heated strongly in a boiling tube, over a non-luminous Bunsen flame, until there is no further change in the mass.

1. Weigh accurately about 4.5 g of **FA 3** in the boiling tube provided. Record your weighings in the space provided below.
2. Heat the tube gently first, then strongly.
3. Place the boiling tube into a **dry** 250 cm³ beaker to cool.

You may wish to proceed with other experiments while waiting for the boiling tube to cool.

4. Weigh and record the mass of the cooled boiling tube containing the residue.
5. Repeat points **2** to **4** as necessary until a constant mass is obtained.
6. **Turn off your Bunsen burner.**

(i) In an appropriate format in the space below, record all weighings measurements.

[3]

- (ii) Using your results, calculate the mass of carbon dioxide and water vapour evolved.

For
Examiner's
Use

mass of CO_2 and H_2O evolved = [1]

- (iii) Using your answer to **(a)(ii)**, calculate the amount of carbon dioxide evolved.

[A_r : H, 1.0; C, 12.0; O, 16.0]

amount of CO_2 evolved = [1]

- (iv) Calculate the mass of sodium hydrogencarbonate in the sample of **FA 3**.

[A_r : H, 1.0; C, 12.0; O, 16.0; Na, 23.0]

mass of NaHCO_3 in sample of **FA 3** = [1]

- (v) Determine the percentage by mass of sodium hydrogencarbonate in **FA 3**.

percentage by mass of NaHCO_3 in **FA 3** = [1]

- (b) Suggest one possible source of error in this experiment. How would this error affect the calculated results in (a)(iv)?

For
Examiner's
Use

.....

.....

.....

.....

..... [2]

(c) **Planning**

Plan an experiment to determine the percentage by mass of sodium hydrogencarbonate in the unknown sample based on volumetric analysis method.

In this experiment, you will titrate a **solution of FA 3** against **FA 1**, using a suitable indicator.

You can assume you are provided with the following reagent:

FA 4 is a solution containing 30.00 g dm^{-3} of **FA 3**.

In your plan, you should include details of

- the amount of reagents you would use,
- the apparatus you would use and the procedure you would follow,
- the measurements you would take,
- appropriate calculations to show how the percentage by mass of sodium hydrogencarbonate in **FA 3** can be determined, assuming the average titre is $y \text{ cm}^3$.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

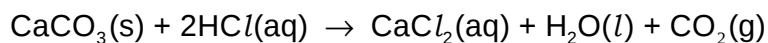
..... [6]

[Total : 15]

3 Investigation of the kinetics of the reaction between calcium carbonate and hydrochloric acid

For
Examiner's
Use

Calcium carbonate that reacts with hydrochloric acid in an acid-carbonate reaction as shown below.



FA 5 is powdered CaCO_3 .

In this question, you will measure the volume of CO_2 gas produced at timed intervals until the reaction is complete, using an excess of dilute hydrochloric acid.

You will need access to **FA 1** solution you used earlier.

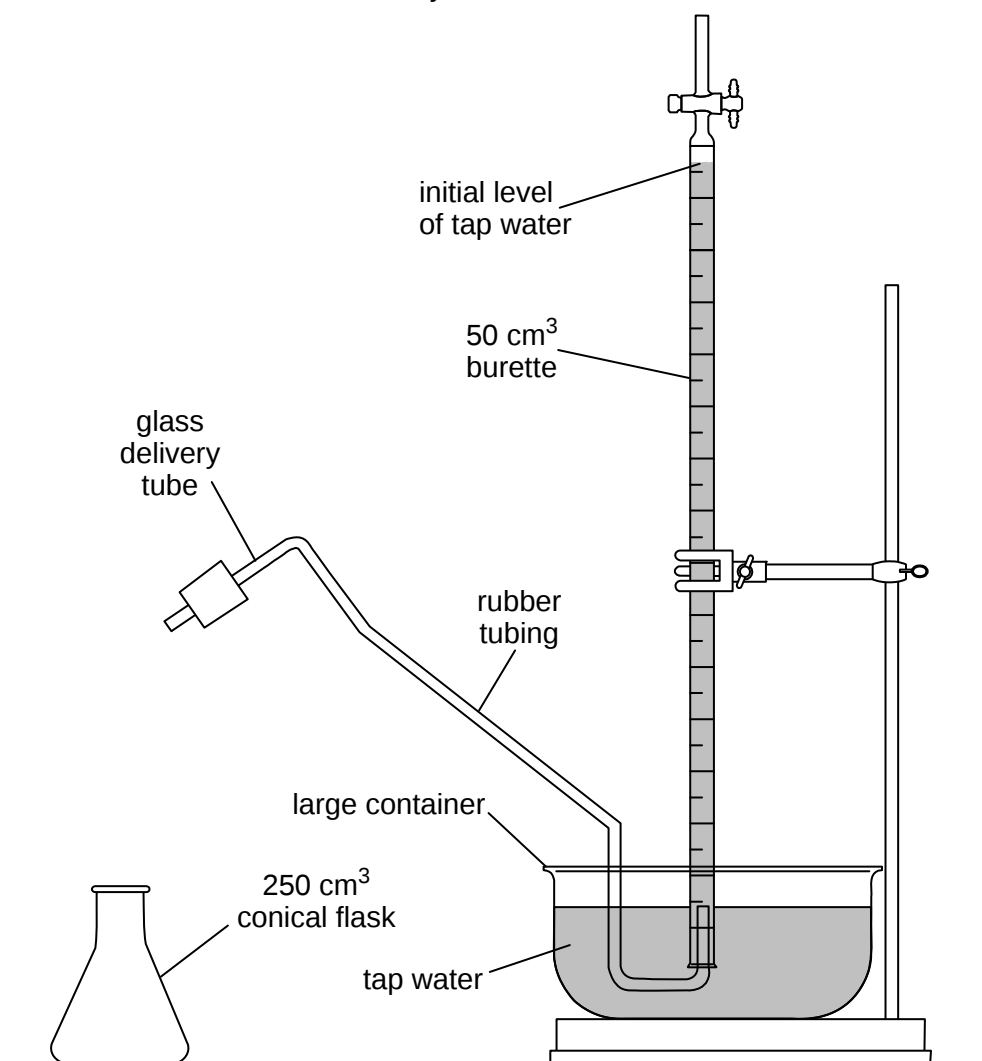


Fig 3.1

You will measure the level of water in the burette at timed intervals.

In an appropriate format in the space provided on page **11**, prepare a table in which you may record each burette reading and the time it was taken. The time taken should be recorded to one decimal place.

In addition, your table will need to show the volume of CO_2 collected up to that time, recorded to one decimal place.

1. Set up the apparatus as shown in the Fig. 3.1. You should insert the rubber tubing to a sufficient depth in the burette so that it will not subsequently shake loose.
2. Adjust the water level in the burette until it is between 48.0 cm^3 and 50.0 cm^3 . You may find it helpful to use an empty dropping pipette to introduce small amounts of air from the bottom of the burette tube.
3. Transfer all the solid **FA 5** provided in the weighing bottle into a dry and clean 250 cm^3 conical flask.
4. Use an appropriate measuring cylinder, measure 40 cm^3 of **FA 1**.
5. Transfer the **FA 1** into the conical flask containing **FA 5** and insert the bung into the conical flask.
6. Allow any bubbles created in the burette when the bung was inserted in the conical flask to rise to the top. Start the stopwatch, read and record the initial water level in the burette.

Note: Once you have started the stopwatch, allow it to continue running for the duration of the experiment. You **must not stop** the stopwatch until the reaction is complete.
7. Check that the rubber tubing is securely positioned in the burette.
8. Hold the flask by its neck and **gently swirl** it continuously.
9. At $t = 0.5\text{ min}$, read and record the water level in the burette, to 1 decimal place, together with the time it was measured, in your table.
10. Continue to gently swirl the flask. Read and record the water level in the burette every half minute, until the reaction is complete.

(a) (i) Experimental Results

[3]

- (ii) Plot on the grid below, a graph of the volume of CO_2 on the y -axis, against time, t , on the x -axis.

Draw the most appropriate best-fit curve, taking into account all of your points.

For
Examiner's
Use

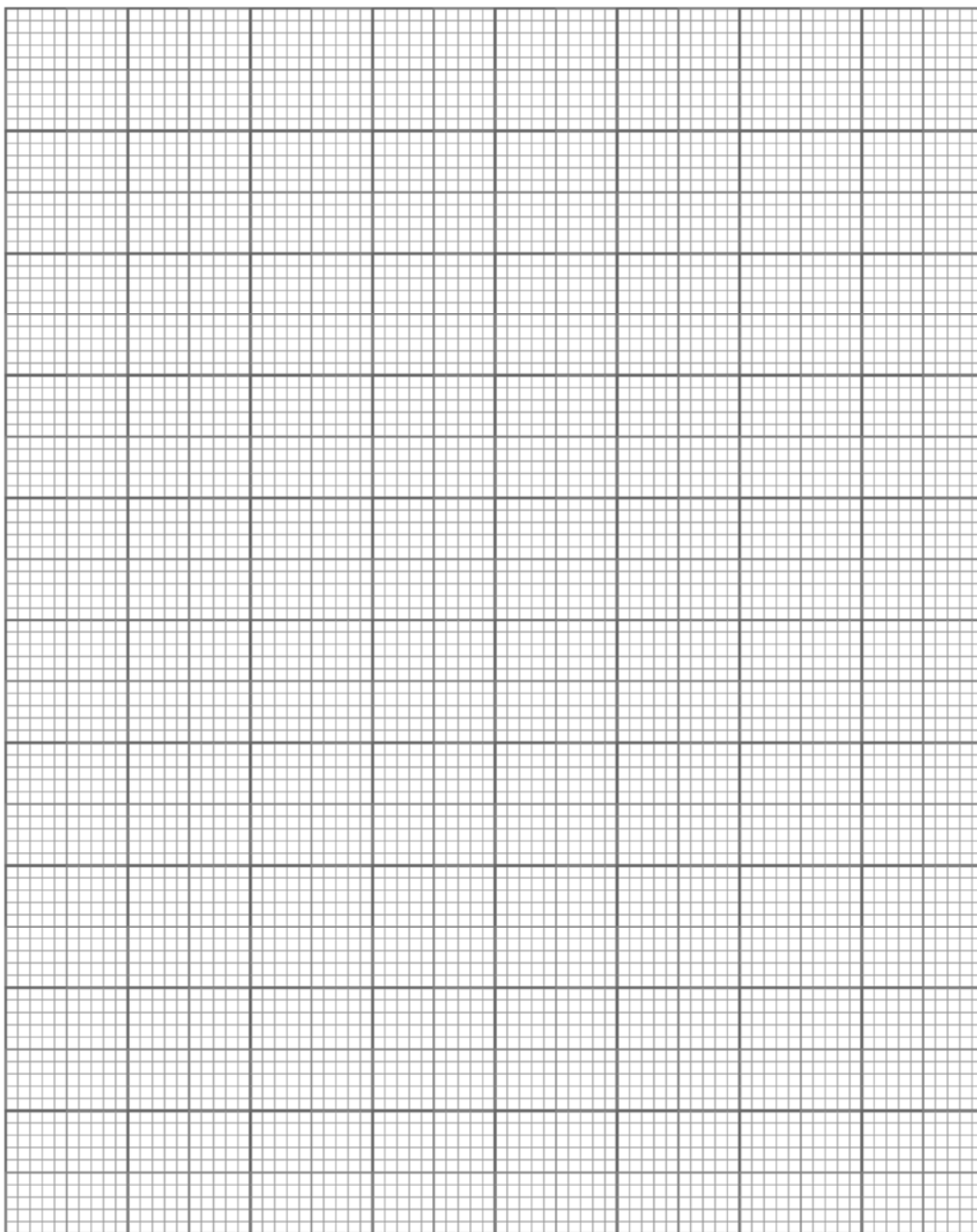


Fig. 3.2

[3]

- (iii) It has been claimed that the reaction between calcium carbonate and hydrochloric acid is pseudo-first order with respect to calcium carbonate.

For
Examiner's
Use

State whether you agree or disagree with this claim. Use evidence from your graph in Fig. 3.2 to support your answer.

.....

.....

.....

.....

.....

..... [2]

(b) Planning

Besides using the continuous measurement method in **3(a)** to determine the order of reaction of a reactant, the initial rates method can also be used.

Plan an investigation, which **does not** involve graph plotting, to determine the order of reaction with respect to hydrochloric acid, HCl , using the initial rates method.

You are provided the following chemicals and apparatus:

- same apparatus used in the experimental setup in **3(a)**,
- $2.00 \text{ mol dm}^{-3} \text{ HCl}$ solution
- **FA 5** powdered CaCO_3
- stopwatch

In your plan, you should include details of:

- the different concentrations of the reactants used and the conditions of the experiment,
- the procedure you would follow, including the end-point of the experiment
- the measurements you would take,
- an outline of how you would use your results to determine the order of reaction with respect to HCl .

You may use the space below to draw a table indicating the headers of the measurements and calculations you would be performing.

[Total: 14]

4 Carry out the following experiments with **FA 6**.

In all tests the reagents should be added gradually until no further change is observed unless you are instructed otherwise.

Observations should include:

- (i) descriptions of colour changes and precipitates;
- (ii) names of gases evolved and details of the test used to identify each one.

You should indicate clearly at which stage in a test a change occurs, writing any deductions that you make alongside the observations upon which they are based.

Marks will be given *only* for the prescribed tests and will *not* be given for chemical equations.

For
Examiner's
Use

TEST	OBSERVATION	CONCLUSION
Tests of FA 6 (a) Heat FA 6 in a test-tube until no further change is observed. Allow the residue to cool and retain it for (b). You may wish to proceed with the tests in 4(c) while waiting for the residue to cool.		
(b) Dissolve the residue from test (a) in deionised water and use separate portions of the solution for tests (i) to (iii)		
(i) Add aqueous silver nitrate to a portion of the solution. Then add aqueous ammonia.		

TEST	OBSERVATION	CONCLUSION
(ii) Add a few drops of aqueous potassium manganate(VII) followed by dilute sulfuric acid.		
(iii) Add a few crystals of FA 6 , shake to dissolve and then add dilute sulfuric acid.		
(c) Dissolve FA 6 in water and use separate portions of the solution for tests (i) and (ii).		
(i) Add a few drops of aqueous potassium manganate(VII) followed by dilute sulfuric acid.		
(ii) Add aqueous potassium bromide followed by dilute sulfuric acid. Add hexane and shake the mixture.		

For
Examiner's
Use

You are *not* required to identify **FA 6**.

[7]

- (d) (i) **FA 6** and the residue from (a) contains element **X** in two different oxidation states. Using your observations from the tests in (b) and (c), explain which compound, **FA 6** or the residue, contains **X** in the higher oxidation state.

For
Examiner's
Use

.....

.....

.....

.....

.....

..... [2]

- (ii) The reaction in test (b)(iii) is said to be a **comproportionation** reaction. In light of your observations to test (b)(i) and (b)(iii), together with your answer to (d)(i), suggest what the term **comproportionation** may refer to.

.....

.....

.....

.....

.....

..... [2]

[Total: 11]

BLANK PAGE

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