Write your name, centre number and candidate number in the boxes below.

Surname	Other names

Centre number | | | | | |

Candidate number | | | | |

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Chemical analysis

Time allowed: 2 hours

Subject code **0620**

Chemistry

Questions from Paper 4 and Paper 6

You must have: a ruler marked in centimetres and millimetres, a protractor, compasses, a pen, an HB pencil and an eraser.

Total marks

/ 80

Instructions

- Answer every question in the space provided on this paper.
- Write in black or dark blue ink. Pencil may be used for diagrams and graphs.
- Fill in your name, centre number and candidate number above.
- Show your working: a correct method can earn marks even if the answer is wrong.

Information

- This paper has 10 questions worth 80 marks in total.
- The marks for each question or part are shown in brackets, for example [3].

Advice

- Read every question through once before you write anything.
- Use the marks in brackets to judge how long to spend on each part.
- If you finish early, go back and check your working.

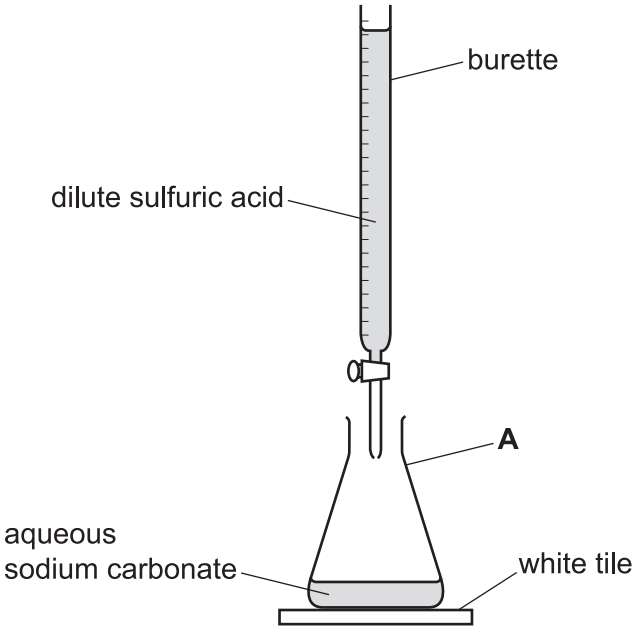
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Print at 100% (Actual size) so diagrams keep their real measurements.

1 A student investigated the volume of dilute sulfuric acid that would react with 25.0 cm^3 of aqueous sodium carbonate.

- A burette was rinsed with water and then with dilute sulfuric acid.
- The burette was filled with dilute sulfuric acid. Some of the dilute sulfuric acid was run out of the burette so that the level of the dilute sulfuric acid was on the burette scale.
- 25.0 cm^3 of aqueous sodium carbonate was poured into the apparatus labelled **A** in the diagram.
- Five drops of methyl orange indicator were added to the aqueous sodium carbonate in **A**.
- The apparatus labelled **A** was placed on a white tile.
- The dilute sulfuric acid was added slowly to the 25.0 cm^3 of aqueous sodium carbonate until the colour of the methyl orange changed from yellow to orange.

The apparatus was arranged as shown in the diagram.



(a) Name the apparatus labelled **A**.

..... [1]

(b) State **one** safety precaution that should be taken when using dilute sulfuric acid.

..... [1]

(c) Give a reason why the white tile is used.

..... [1]

(d) Describe what should be done to the apparatus labelled **A** as the dilute sulfuric acid is added to the aqueous sodium carbonate.

..... [1]

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(e) State why the burette was rinsed with water and then with dilute sulfuric acid at the start of the experiment.

water .....

.....

dilute sulfuric acid .....

.....

[2]

[Total: 6]

Acid-base titrations Click for more variations

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1(a)	(conical) flask	**1**
1(b)	safety glasses/goggles/gloves/lab coat	**1**
1(c)	to see colour change clearly/easily/accurately/better	**1**
1(d)	swirl the flask	**1**
1(e)	water: to clean / to remove residue from previous experiment	**1**
	acid: to remove the water	**1**

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2 This question is about ions and ionic compounds.

(a) Choose from the following list of ions to answer the questions.

Br^-	Ca^{2+}	Cl^-	Cr^{3+}	Cu^{2+}
K^+	Li^+	Na^+	SO_3^{2-}	SO_4^{2-}

Each ion may be used once, more than once or not at all.

State which ion:

(i) gives a lilac colour in a flame test ..... [1]

(ii) forms a grey-green precipitate with aqueous ammonia ..... [1]

(iii) forms a white precipitate with aqueous sodium hydroxide ..... [1]

(iv) forms a cream precipitate with acidified aqueous silver nitrate ..... [1]

(v) forms a white precipitate with acidified aqueous barium nitrate. ..... [1]

(b) Describe how to do a flame test on a sample of a salt.

.....

.....

.....

..... [2]

(c) Magnesium phosphate contains magnesium ions, Mg^{2+}, and phosphate ions, PO_4^{3-}.

Deduce the formula of magnesium phosphate.

..... [1]

[Total: 8]

Tests for ions and gases Click for more variations

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2(a)(i)	K^+	**1**
2(a)(ii)	Cr^{3+}	**1**
2(a)(iii)	Ca^{2+}	**1**
2(a)(iv)	Br^-	**1**
2(a)(v)	SO_4^{2-}	**1**
2(b)	(compound / salt) on wooden splint **or** (nichrome / platinum) wire (1) into (roaring) Bunsen flame (1)	**2**
2(c)	$Mg_3(PO_4)_2$	**1**

3 A student tests two solids: solid **E** and solid **F**.

Tests on solid E

Solid **E** is ammonium sulfate.

Record the expected observations.

The student dissolves solid **E** in distilled water to form solution **E**. The student divides solution **E** into three approximately equal portions.

(a) (i) To the first portion of solution **E**, the student adds about $2\,cm^3$ of aqueous sodium hydroxide. The student warms the mixture gently and tests any gas produced.

observations .....

..... [1]

(ii) Identify the gas given off in **(a)(i)**.

..... [1]

(b) To the second portion of solution **E**, the student adds about $1\,cm^3$ of dilute nitric acid followed by a few drops of aqueous barium nitrate.

observations .....

..... [1]

(c) To the third portion of solution **E**, the student adds a few drops of acidified aqueous potassium manganate(VII).

observations .....

..... [1]

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Tests on solid F

Table 3.1 shows the tests and the student's observations for solid **F**.

Table 3.1

tests	observations
test 1 Carry out a flame test on solid **F**.	yellow flame
test 2 Dissolve the remaining solid **F** in distilled water to form solution **F**. Divide solution **F** into three portions. To the first portion of solution **F**, add about 1 cm^3 of dilute nitric acid followed by a few drops of aqueous silver nitrate.	yellow precipitate forms
test 3 To the second portion of solution **F**, add aqueous sodium hydroxide dropwise until in excess.	white precipitate forms the precipitate dissolves in excess aqueous sodium hydroxide to form a colourless solution
test 4 To the third portion of solution **F**, add aqueous ammonia dropwise until in excess.	white precipitate forms the precipitate dissolves in excess aqueous ammonia to form a colourless solution

(d) Identify the **three** ions in solid **F**.

.....

.....

..... [3]

[Total: 7]

Tests for ions and gases Click for more variations

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3(a)(i)	(damp red) litmus (paper) turns blue	1
3(a)(ii)	ammonia / NH_3	1
3(b)	white precipitate	1
3(c)	(solution) becomes pink	1
3(d)	**M1** sodium / Na^+ **M2** zinc / Zn^{2+} **M3** iodide / I^-	3

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4 A student tests two substances: solid **R** and solid **S**.

Tests on solid R

Table 3.1 shows the tests and the student's observations for solid **R**.

Table 3.1

tests	observations
test 1 Gently heat about half of solid **R** in a boiling tube.	the white solid forms a colourless liquid steam comes out from the boiling tube and condensation forms at the top of the boiling tube
test 2 The remaining solid **R** is dissolved in distilled water to form solution **R**. Solution **R** is divided into four portions. To the first portion of solution **R**, add aqueous sodium hydroxide dropwise and then in excess.	white precipitate forms the white precipitate dissolves in excess aqueous sodium hydroxide
test 3 To the second portion of solution **R**, add aqueous ammonia dropwise and then in excess.	white precipitate forms the white precipitate remains in excess aqueous ammonia
test 4 To the third portion of solution **R**, add 1 cm^3 of dilute nitric acid followed by a few drops of aqueous barium nitrate.	no change
test 5 To the fourth portion of solution **R**, add 1 cm^3 of dilute nitric acid followed by a few drops of aqueous silver nitrate.	cream precipitate forms

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(a) State the conclusion that can be made from the observations in **test 1**.

..... [1]

(b) Identify solid **R**.

.....

..... [2]

Tests on solid S

Solid **S** is sodium sulfite.

Record the expected observations.

(c) The student carries out a flame test on solid **S**.

observations ..... [1]

The student dissolves the remaining solid **S** in distilled water to form solution **S**.
The student divides solution **S** into two portions.

(d) To the first portion of solution **S**, the student adds about 2 cm^3 of aqueous sodium hydroxide.

observations ..... [1]

(e) To the second portion of solution **S**, the student adds a few drops of acidified aqueous potassium manganate(VII).

observations ..... [1]

[Total: 6]

Tests for ions and gases Click for more variations

Reduced to 78% to fit the page (wider than A4).

4(a)	(**R** is) hydrated / has water of crystallisation	**1**
4(b)	**M1** aluminium / Al^{3+} **M2** bromide / Br^-	**2**
4(c)	yellow (flame)	**1**
4(d)	no change / no reaction / remains colourless	**1**
4(e)	becomes colourless / (pink / purple) is decolourised	**1**

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5 A student tests two solids: solid **F** and solid **G**.

Tests on solid F

Solid **F** is calcium carbonate.

(a) The student adds about 15 cm^3 of dilute hydrochloric acid to the sample of solid **F** in a boiling tube and tests any gas produced.

observations .....

.....

..... [2]

(b) The student filters the product from **(a)** to obtain solution **H** as the filtrate.
The student divides solution **H** into three approximately equal portions in three test-tubes.

(i) To the first portion of solution **H**, the student adds about 1 cm depth of dilute nitric acid followed by a few drops of aqueous barium nitrate.

observations .....

..... [1]

(ii) To the second portion of solution **H**, the student adds aqueous sodium hydroxide dropwise and then in excess.

observations when added dropwise .....

observations in excess .....
[2]

(iii) To the third portion of solution **H**, the student adds about 1 cm depth of dilute nitric acid followed by a few drops of aqueous silver nitrate.

observations .....

..... [1]

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Tests on solid G

Table 3.1 shows the tests and the student's observations for solid **G**.

Table 3.1

tests	observations
test 1 Do a flame test on solid **G**.	lilac coloured flame
test 2 Dissolve the remaining solid **G** in water to form solution **G**. Divide solution **G** into three portions. To the first portion of solution **G**, add about 1 cm^3 of aqueous chlorine.	orange solution forms
test 3 To the second portion of solution **G**, add about 1 cm^3 of aqueous sodium hydroxide.	remains colourless
test 4 To the third portion of solution **G**, add about 1 cm^3 of dilute nitric acid followed by a few drops of aqueous silver nitrate.	cream precipitate forms

(c) Identify solid **G**.

.....

..... [2]

[Total: 8]

Tests for ions and gases Click for more variations

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5(a)	**M1** limewater becomes milky	**1**
	M2 effervescence / fizzing / bubbling	**1**
5(b)(i)	no change	**1**
5(b)(ii)	dropwise: white precipitate	**1**
	excess: no (further) change / precipitate remains / white precipitate / insoluble	**1**
5(b)(iii)	white precipitate	**1**
5(c)	**M1** potassium / K^+ **M2** bromide / Br^-	**1**
	KBr = 2	**1**

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6 Solid **M** and solid **N** were analysed. Solid **M** was iron(III) nitrate.
Tests were done on each substance.

tests on solid M

Complete the expected observations.

Solid **M** was dissolved in water to form solution **M**. Solution **M** was divided into two approximately equal portions in two test-tubes.

(a) To the first portion of solution **M**, aqueous sodium hydroxide was added gradually until in excess. The product was kept for **(b)**.

observations .....

..... [2]

(b) (i) The product from **(a)** was transferred to a boiling tube. A piece of aluminium foil was added and the mixture warmed gently. Any gas produced was tested.

observations .....

..... [1]

(ii) Identify the gas made in **(i)**.

..... [1]

(c) To the second portion of solution **M**, about 1 cm depth of dilute nitric acid followed by a few drops of aqueous barium nitrate were added.

observations ..... [1]

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tests on solid N

tests	observations
test 1 A flame test was carried out on solid **N**.	the flame became red
Solid **N** was dissolved in water to form solution **N**. Solution **N** was divided equally into one test-tube and one boiling tube. **test 2** About 1 cm depth of dilute nitric acid followed by a few drops of aqueous silver nitrate were added to the first portion of solution **N** in a test-tube.	no visible change
test 3 About 2 cm depth of dilute hydrochloric acid was added to the second portion of solution **N**. The mixture was warmed and any gas produced was tested.	acidified aqueous potassium manganate(VII) changed from purple to colourless

(d) Identify the gas produced in **test 3**.

..... [1]

(e) Identify solid **N**.

.....

..... [2]

[Total: 8]

Tests for ions and gases Click for more variations

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6(a)	brown precipitate or red-brown precipitate	**1**
	remains / does not (re)dissolve (in excess)	**1**
6(b)(i)	(red) litmus turns blue	**1**
6(b)(ii)	ammonia / NH_3	**1**
6(c)	no change / no precipitate / no reaction	**1**
6(d)	sulfur dioxide / SO_2	**1**
6(e)	lithium sulfite / Li_2SO_3	**2**

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7 *Greaseaway* and *Kitchenclean* are two solutions used as household cleaners that contain aqueous ammonia.

Plan an investigation to find which of the two household cleaners contains aqueous ammonia with the highest concentration. Assume that aqueous ammonia is the only alkali in the cleaners.

Include in your plan:

- the method you will use
- how your results will be used to determine which household cleaner contains aqueous ammonia with the highest concentration.

You are provided with common laboratory apparatus and chemicals.

....

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.... [6]

Acid-base titrations Click for more variations

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7	**any 6 from:** **MP1** known / stated volume of one cleaner **MP2** measured with appropriate named apparatus (pipette / measuring cylinder / burette) **MP3** named indicator used in this experiment **MP4** acid added to cleaner in flask **MP5** correct end-point colour for indicator used stated **MP6** recorded / measured start and end reading on burette **MP7** biggest volume (of acid) used has most concentrated ammonia	**6**

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8 A student tests two substances: solution **F** and solid **G**.

Tests on solution F

Table 3.1 shows the tests and the student's observations for solution **F**. The student divides solution **F** into three portions.

Table 3.1

tests	observations
test 1 Do a flame test on the first portion of solution **F**.	light green colour
test 2 To the second portion of solution **F**, add a 1 cm depth of aqueous sodium hydroxide and a piece of aluminium foil. Warm the mixture gently and test any gas produced.	effervescence was seen; the gas turned damp red litmus paper blue
test 3 To the third portion of solution **F**, add a 1 cm depth of dilute nitric acid followed by a few drops of aqueous silver nitrate.	no change

(a) Describe how to do the flame test used in **test 1**.

.....

.....

..... [2]

(b) Identify the gas given off in **test 2**.

..... [1]

(c) Identify solution **F**.

.....

..... [2]

(d) State what would be observed if the student adds dilute sulfuric acid to another portion of solution **F**.

observations .....

..... [1]

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Tests on solid G

Solid **G** is iron(II) carbonate.

(e) About 10 cm^3 of dilute sulfuric acid is added to solid **G**.
Any gas given off is tested.

observations .....

.....

..... [2]

(f) To the product from **(e)**, aqueous sodium hydroxide is added dropwise until in excess.

observations adding dropwise .....

observations in excess .....
[2]

[Total: 10]

Tests for ions and gases Click for more variations

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8(a)	**M1** use of a wire / splint to get substance into a flame	1
	M2 putting sample INTO flame **and** identifying (Bunsen) flame as roaring / blue / non-luminous / hot	1
8(b)	ammonia / NH_3	1
8(c)	**M1** barium / Ba^{2+}	1
	M2 nitrate / NO_3^-	1
8(d)	white precipitate	1
8(e)	**M1** fizzing / bubbles / effervescence	1
	M2 limewater becomes milky	1
8(f)	**M1** green precipitate	1
	M2 remains in excess / does not dissolve / green precipitate	1

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9 A student tests two solids: solid **T** and solid **U**.

Tests on solid T

Solid **T** is lithium sulfite.

Complete the expected observations.

(a) The student carries out a flame test on solid **T**.

observations ..... [1]

The student dissolves the remaining solid **T** in water to form solution **T**.

The student divides solution **T** into two portions.

(b) The student adds the first portion of solution **T** to a test-tube containing acidified aqueous potassium manganate(VII).

State the colour change.

from ..... to ..... [2]

(c) **(i)** To the second portion of solution **T**, the student adds excess dilute nitric acid.
The gas produced turns filter paper soaked in acidified aqueous potassium manganate(VII) white.

Identify the gas produced.

..... [1]

(ii) To the solution produced in **(c)(i)**, the student adds aqueous barium nitrate.

observations ..... [1]

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Tests on solid U

Solid **U** contains one cation and one anion.
Table 3.1 shows the tests and the student's observations for solid **U**.

The student dissolves solid **U** in distilled water to form solution **U**. The student then divides solution **U** into three portions.

Table 3.1

tests	observations
test 1 To the first portion of solution **U**, add a few drops of aqueous ammonia.	green precipitate
test 2 To the second portion of solution **U**, add 1 cm^3 of dilute nitric acid followed by a few drops of aqueous silver nitrate.	yellow precipitate
test 3 To the third portion of solution **U**, add 1 cm^3 of aqueous chlorine.	the solution turns brown

(d) Identify **two** cations that the tests and observations in Table 3.1 show could be in solid **U**.

.....

..... [2]

(e) Describe an additional test that the student could do to confirm which one of the two cations identified in **(d)** is in solid **U**.
Give the expected result for **one** of the cations.

test .....

cation .....

result .....
[2]

(f) Identify the anion in solid **U**.

..... [1]

[Total: 10]

Tests for ions and gases Click for more variations

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9(a)	red (flame colour)	**1**
9(b)	**M1** (from) purple **M2** (to) colourless	**2**
9(c)(i)	sulfur dioxide / SO_2	**1**
9(c)(ii)	no change	**1**
9(d)	**M1** iron(II) / Fe^{2+} **M2** chromium(III) / Cr^{3+}	**2**

9(e)	**M1** add (excess / more) aqueous sodium hydroxide **M2** chromium(III) **AND** forms a solution / precipitate dissolves **OR** **M2** iron(II) **AND** forms a green precipitate / precipitate does not dissolve / (precipitate) becomes brown **OR** **M1** leave to stand / add more (aqueous ammonia) **M2** chromium(III) **AND** remains green / does not turn brown **OR** **M2** iron(II) **AND** turns brown	**2**
9(f)	iodide / I^-	**1**

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10 Two aqueous solutions, **M** and **N**, were analysed. Solution **N** was aqueous sodium hydroxide. The tests on **M** and **N**, and some of the observations are in the following table. Complete the observations in the table.

tests	observations
<u>tests on solution **M**</u> Solution **M** was divided into four equal portions in separate test-tubes. **(a)** Appearance of solution **M**. The pH of the first portion of **M** was tested.	 colourless liquid pH 1
(b) Calcium carbonate was added to the second portion of **M**. The gas given off was tested with a splint.	effervescence lighted splint extinguished
(c) Magnesium ribbon was added to the third portion of **M**. The gas given off was tested with a splint.	effervescence lighted splint popped
(d) A few drops of dilute nitric acid and aqueous silver nitrate were added to the fourth portion of **M**.	white precipitate

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tests	observations
<u>tests on solution **N**</u> Solution **N** was divided into three equal portions in separate test-tubes. **(e)** Appearance of solution **N**. The pH of the first portion of solution **N** was tested.	..... [1] pH = [1]
(f) Drops of aqueous zinc sulfate were added to the second portion of **N** and the mixture was shaken. Excess aqueous zinc sulfate was then added to the mixture and the mixture was shaken.	..... [1] ..... [2]
(g) Ammonium chloride was added to the third portion of **N**. The mixture was warmed and the gas tested with damp red litmus paper.	.... [2]

(h) **(i)** Identify the gas given off in test **(c)**.

..... [1]

(ii) Identify the gas given off in test **(g)**.

..... [1]

(i) Identify solution **M**.

..... [2]

[Total: 11]

Tests for ions and gases Click for more variations

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10 tests on solution **N**

(e) appearance colourless (1) [1]
pH 11–14 (1) [1]

(f) colourless / no change (1)
white (1)
precipitate (1) [3]

(g) litmus paper turns blue (1)
pungent smell (1) [2]

(h) **(i)** hydrogen / H_2 (1) [1]

(ii) ammonia (1) [1]

(i) hydrochloric acid (2) [2]
acid or chloride only, 1 mark.

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