Notes for use in qualitative analysis
Tests for anions

anion	test	test result
carbonate (CO_3^{2-})	add dilute acid	effervescence, carbon dioxide produced
chloride (Cl^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	white ppt.
bromide (Br^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	cream ppt.
iodide (I^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	yellow ppt.
nitrate (NO_3^-) [in solution]	add aqueous sodium hydroxide, then aluminium foil; warm carefully	ammonia produced
sulfate (SO_4^{2-}) [in solution]	acidify, then add aqueous barium nitrate	white ppt.
sulfite (SO_3^{2-})	add dilute hydrochloric acid, warm gently and test for the presence of sulfur dioxide	sulfur dioxide produced will turn acidified aqueous potassium manganate(VII) from purple to colourless

Tests for aqueous cations

cation	effect of aqueous sodium hydroxide	effect of aqueous ammonia
aluminium (Al^{3+})	white ppt., soluble in excess, giving a colourless solution	white ppt., insoluble in excess
ammonium (NH_4^+)	ammonia produced on warming	–
calcium (Ca^{2+})	white ppt., insoluble in excess	no ppt., or very slight white ppt.
chromium(III) (Cr^{3+})	green ppt., soluble in excess	grey-green ppt., insoluble in excess
copper(II) (Cu^{2+})	light blue ppt., insoluble in excess	light blue ppt., soluble in excess, giving a dark blue solution
iron(II) (Fe^{2+})	green ppt., insoluble in excess	green ppt., insoluble in excess
iron(III) (Fe^{3+})	red-brown ppt., insoluble in excess	red-brown ppt., insoluble in excess
zinc (Zn^{2+})	white ppt., soluble in excess, giving a colourless solution	white ppt., soluble in excess, giving a colourless solution

Tests for gases

gas	test and test result
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	turns limewater milky
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 acidified aqueous potassium manganate(VII) from purple to colourless

Flame tests for metal ions

metal ion	flame colour
lithium, Li^+	red
sodium, Na^+	yellow
potassium, K^+	lilac
calcium, Ca^{2+}	orange-red
barium, Ba^{2+}	light green
copper(II), Cu^{2+}	blue-green

1 Two substances, **C** and **D**, were analysed. Solid **C** was a salt and solution **D** was an aqueous solution of chromium(III) chloride.
The tests on solid **C**, and some of the observations, are in the following table.

tests	observations
tests on solid **C** Solid **C** was added to distilled water in a test-tube and shaken to dissolve. The solution was divided into two portions in test-tubes, and the following tests carried out. Appearance of the solution. The pH of the first portion of the solution was tested.	 colourless liquid pH = 7
Dilute nitric acid was added to the second portion of the solution followed by aqueous silver nitrate.	cream precipitate
A flame test was carried out on solid **C**.	yellow flame colour

(a) Identify solid **C**.

..... [2]

(b) Describe the appearance of solution **D**.

..... [1]

(c) Tests were carried out on solution **D**.

Complete the observations for tests 1, 2 and 3.

(i) **test 1**

Drops of aqueous sodium hydroxide were added to solution **D**.

Excess aqueous sodium hydroxide was then added to the mixture.

observations .....

..... [3]

(ii) test 2

Excess aqueous ammonia was added to solution **D**.

observations ..... [2]

(iii) test 3

Dilute nitric acid was added to solution **D** followed by aqueous silver nitrate.

observations ..... [1]

(d) Chromium(III) can be converted to chromium(VI). Chromium(VI) is hazardous.

Suggest **one** safety precaution when using chromium(VI).

..... [1]

[Total: 10]

2 Two solids, **L** and **M**, were analysed. Solid **L** was copper(II) chloride and solid **M** was a different salt.
The tests on the solids, and some of the observations, are shown.

tests on solid L

(a) Describe the appearance of solid **L**.

observation ..... [1]

(b) Distilled water was added to solid **L** and shaken to dissolve.

The solution was divided into four equal portions in four test-tubes and the following tests carried out.

(i) Drops of aqueous ammonia were added to the first portion of the solution.

Excess ammonia solution was then added to the mixture and shaken.

observation .....

.....

.....

..... [4]

(ii) Excess aqueous sodium hydroxide was added to the second portion of the solution.

observation .....

..... [1]

(iii) Dilute nitric acid was added to the third portion of the solution followed by aqueous silver nitrate.

observation ..... [1]

(iv) Dilute nitric acid was added to the fourth portion of the solution followed by aqueous barium nitrate.

observation ..... [1]

tests on solid M

Tests are carried out and the following observations made.

tests on solid **M**	observations
Appearance of the solid.	white crystals
The solid was heated and the gas given off was tested with damp red litmus paper.	a sublimate formed on the sides of the test-tube litmus paper turned blue
Solid **M** was dissolved in water to form a solution. Aqueous sodium hydroxide was added to the solution and the mixture heated. The gas given off was tested.	 pungent gas evolved pH paper showed pH 10
Dilute nitric acid was added to the solution followed by aqueous silver nitrate.	yellow precipitate

(c) Identify solid **M**.

.....

..... [2]

[Total: 10]

6 A solid **D**, which is a soluble metal sulfate, was analysed.
The tests on **D**, and some of the observations, are in the following table.
Complete the observations in the table.

tests	observations
<u>tests on solid **D**</u> **(a) (i)** Appearance of solid **D**.	pale green crystals
(ii) Solid **D** was heated in a test-tube gently and then strongly.	condensation formed at the top of the test-tube
<u>tests on the aqueous solution</u> Solid **D** was added to distilled water and shaken to dissolve. The solution was divided into four equal portions in separate test-tubes. **(b) (i)** Several drops of aqueous sodium hydroxide were added to the first portion of the solution.	green precipitate
Excess aqueous sodium hydroxide was added to the mixture.	green precipitate remained
(ii) Excess aqueous ammonia was added to the second portion of the solution.	green precipitate
(c) Aqueous silver nitrate and dilute nitric acid were added to the third portion of the solution.	..... [1]
(d) Aqueous barium nitrate and dilute nitric acid were added to the fourth portion of the solution.	..... [2]

(e) What does test **(a)** tell you about solid **D**?

..... [2]

(f) What conclusions can you draw about the identity of solid **D**?

.....

..... [3]

[Total: 8]

2 Two liquids, **L** and **M**, were analysed. **L** was aqueous potassium iodide. **M** was a colourless liquid.
The tests on the liquids and some of the observations are in the following table.
Complete the observations in the table.

tests	observations
tests on liquid **L** **(a)** Appearance of liquid **L**.	..... [1]
Liquid **L** was divided into three equal portions in separate test-tubes. **(b) (i)** An iodine crystal was added to the first portion of liquid **L**. The test-tube was stoppered and the contents shaken. **(ii)** An equal volume of liquid **M** was added to the test-tube, the contents shaken and left to stand for five minutes.	liquid turned orange two layers were formed, pink top layer and orange lower layer
(c) To the second portion of liquid **L**, dilute nitric acid and barium nitrate solution were added.	..... [1]
(d) To the third portion of liquid **L**, dilute nitric acid and silver nitrate solution were added.	..... [2]

(e) Why does the colour of liquid **L** change in test **(b)(i)**?

.....

..... [1]

(f) What conclusions can you draw about liquid **M** from test **(b)(ii)**?

.....

..... [2]

[Total: 7]

3 A mixture of two solids, **M** and **N**, was analysed.
Solid **M** was zinc sulfate which is water-soluble and solid **N** was insoluble.
The tests on the mixture, and some of the observations, are in the table.
Complete the observations in the table.

tests	observations
Distilled water was added to the mixture in a boiling tube and shaken. The contents of the tube were filtered and the filtrate and residue kept for the following tests.	
<u>tests on the filtrate</u> The filtrate was divided into four portions.	
(a) (i) Drops of aqueous sodium hydroxide were added to the first portion of the filtrate. Excess aqueous sodium hydroxide was then added. **(ii)** Drops of aqueous ammonia were added to the second portion of the filtrate. Excess aqueous ammonia was then added.	.... [3] .... [2]
(b) About 1 cm^3 of dilute nitric acid followed by silver nitrate solution was added to the third portion of the filtrate.	..... [1]
(c) About 1 cm^3 of dilute nitric acid followed by barium nitrate solution was added to the fourth portion of the filtrate.	..... [2]

tests	observations
<u>tests on the residue</u> **(d)** Appearance of the residue.	black solid
(e) Dilute hydrochloric acid was added to a little of the residue. The mixture was heated and the gas given off was tested with damp blue litmus paper.	effervescence pungent gas, bleached litmus paper
(f) Aqueous hydrogen peroxide was added to a little of the residue. The gas given off was tested.	effervescence glowing splint relit

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

..... [1]

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

..... [1]

(i) What conclusions can you draw about solid **N**?

.....

..... [2]

[Total: 12]

4 Two different liquids, **M** and **N**, were analysed. **N** was aqueous potassium iodide. The tests on the liquids and some of the observations are in the following table. Complete the observations in the table.

tests	observations
(a) (i) Appearance of liquid **M**.	colourless liquid with an antiseptic smell
(ii) Appearance of liquid **N**.	..... [2]
(b) (i) A few drops of **M** were transferred to a dry watch glass. The liquid was touched with a lighted splint.	burns with a yellow flame
(ii) Test **(b)(i)** was repeated using liquid **N**.	..... [1]
(c) A little of liquid **M** was added to a crystal of iodine in a test-tube. The test-tube was shaken.	orange-brown solution
(d) To a little of liquid **N**, a few drops of dilute nitric acid was added, followed by silver nitrate solution.	..... [2]

(e) What type of substance is liquid **M**?

.....

..... [2]

[Total: 7]

5 Three different liquids **P**, **Q** and **R** were analysed.
P was an aqueous solution of sulfuric acid.
The tests on the liquids and some of the observations are in the following table.
Complete the observations in the table.

tests	observations
(a) (i) Appearance of the liquids.	**P** ..... [1] **Q** colourless, smell of vinegar **R** colourless, no smell
(ii) The pH of the liquids was tested using Universal Indicator paper.	**P** ..... [1] **Q** pH 5 **R** pH 7
(b) A piece of magnesium ribbon was added to a little of each liquid. The gas given off by liquid **P** was tested.	**P** .... [2] **Q** slow effervescence **R** no reaction
(c) To a little of liquid **P**, hydrochloric acid and aqueous barium chloride were added.	..... [2]
(d) Liquid **R** was heated to boiling in a test-tube. A thermometer was used to record the constant temperature of the vapour produced.	temperature = 100 °C

(e) What conclusions can you draw about liquid **Q**?

..... [2]

(f) Identify liquid **R**.

..... [1]

[Total: 9]

1 Solid **E** was analysed. **E** was an aluminium salt.
The tests on the solid and some of the observations are in the following table.
Complete the observations in the table.

tests	observations
tests on solid **E** **(a)** Appearance of solid **E**.	white crystalline solid
(b) A little of solid **E** was heated in a test-tube.	colourless drops of liquid formed at the top of the tube
(c) A little of solid **E** was dissolved in distilled water. The solution was divided into four test-tubes and the following tests were carried out.	
(i) To the first test-tube of solution, drops of aqueous sodium hydroxide were added. Excess sodium hydroxide was then added to the test-tube.	.... [3]
(ii) Test **(i)** was repeated using aqueous ammonia solution instead of aqueous sodium hydroxide.	.... [2]
(iii) To the third test-tube of solution, dilute hydrochloric acid was added, followed by barium chloride solution.	no reaction
(iv) To the fourth test-tube of solution, aqueous sodium hydroxide and aluminium powder were added. The mixture was heated.	effervescence pungent gas given off turned damp litmus paper blue

(d) What does test **(b)** tell you about solid **E**.

.....

..... [1]

(e) Identify the gas given off in test **(c)(iv)**.

..... [1]

(f) What conclusions can you draw about solid **E**?

.....

..... [2]

[Total: 9]

2 Two different solutions, **X** and **Y**, were analysed. **X** was copper sulfate solution.
The tests on the solutions, and some of the observations, are in the following table.

Complete the observations in the table.

tests	observations
tests on solution **X**	
(a) (i) Appearance of solution **X**.	..... [1]
(ii) To a little of solution **X**, aqueous sodium hydroxide was added.	..... [2]
(iii) To a little of solution **X**, aqueous ammonia was added drop by drop and shaken.	..... [1]
Excess aqueous ammonia solution was then added to the test-tube.	.... [2]
tests on solution **Y**	
(b) (i) A little of solution **Y** was tested with Universal Indicator paper. The pH was recorded.	pH1
(ii) To about 3 cm^3 of solution **Y** a few drops of dilute hydrochloric acid and then aqueous barium chloride was added.	white precipitate

(c) Identify solution **Y**.

..... [2]

[Total: 8]

3 Describe a chemical test to distinguish between each of the following pairs of substances. An example is given.

Example: hydrogen and carbon dioxide

test lighted splint

result with hydrogen ..... gives a pop .....

result with carbon dioxide ..... splint is extinguished .....

(a) zinc carbonate and zinc chloride

test .....

result with zinc carbonate .....

result with zinc chloride ..... [2]

(b) ammonia and chlorine

test .....

result with ammonia .....

result with chlorine ..... [3]

(c) aqueous iron(II) sulfate and aqueous iron(III) sulfate

test .....

result with aqueous iron(II) sulfate .....

result with aqueous iron(III) sulfate ..... [3]

[Total: 8]

4 Two solids, **S** and **V**, were analysed. **S** was copper(II) oxide.
The tests on the solids, and some of the observations are in the following table.
Complete the observations in the table. Do not write any conclusions in the table.

test	observation
<u>tests on solid **S**</u> **(a)** Appearance of solid **S**	black solid
(b) Hydrogen peroxide was added to solid **S** in a test-tube.	slow effervescence
A glowing splint was inserted into the tube.	splint relit
(c) Dilute sulfuric acid was added to solid **S** in a test-tube. The mixture was heated to boiling point.	blue solution formed
The solution was divided into three equal portions into test-tubes.	
(i) To the first portion of the solution, excess sodium hydroxide was added.	..... [1]
(ii) To the second portion of the solution, about 1 cm^3 of aqueous ammonia solution was added.	..... [2]
Excess ammonia solution was then added.	..... [2]
(iii) To the third portion of the solution, dilute hydrochloric acid was added followed by barium chloride solution.	..... [2]

test	observation
tests on solid **V** **(d)** Appearance of solid **V**	black solid
(e) Hydrogen peroxide was added to solid **V** in a test-tube.	rapid effervescence
A glowing splint was inserted into the tube.	splint relit

(f) **(i)** Compare the reactivity of solid **S** and solid **V** with hydrogen peroxide.

.....

[1]

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

.....

[1]

(g) What conclusions can you draw about solid **V**?

.....

.....

.....

[2]

[Total: 11]

Question	Answer	Marks
1(a)	sodium; bromide;	2 1 1
1(b)	green	1
1(c)(i)	green; precipitate; with excess, green solution / clear / dissolves;	3 1 1 1
1(c)(ii)	grey-green; precipitate;	2 1 1
1(c)(iii)	white precipitate;	1
1(d)	fume cupboard / protective clothing, e.g. gloves or goggles;	1

Question	Answer	Marks
2(a)	blue / green (solid / crystals);	1
2(b)(i)	(pale) blue; precipitate; royal / deep blue; dissolves / solution;	4
2(b)(ii)	(pale) blue precipitate;	1
2(b)(iii)	white precipitate;	1
2(b)(iv)	no reaction / change / precipitate;	1
2(c)	ammonium; iodide;	2

6 **(c** no reaction / no change / no precipitate (1) [1]

(d) white (1)
precipitate (1) [2]

(e) transition metal present (1)
allow: iron
water / hydrated (1) [2]

(f) hydrated (1) iron (1) (II) (1) (sulfate) [3]

2 tests on liquid L

(a) colourless (liquid) [1]
allow: (pale) yellow

(c) no reaction / change (1) [1]

(d) yellow (1) precipitate (1) [2]

(e) iodine dissolves / owtte (1) [1]

(f) organic (1) solvent (1) liquids do not mix (1) max [2]

3 **(a) (i)** white (1) precipitate (1) dissolves (1) [3]

(ii) white precipitate (1) dissolves (1) [2]

(b) no reaction/change (1) [1]

(c) white (1) precipitate (1) [2]

(g) chlorine (1) **not:** chloride [1]

(h) oxygen (1) [1]

(i) transition metal present (1) catalyst (1) **allow:** copper oxide for one mark [2]

manganese (1) oxide (1) max 2

4 **(a) (ii)** colourless (1) **allow** yellow no smell (1) [2]

(b) (ii) extinguished/owtte (1) [1]

(d) yellow (1) precipitate (1) [2]

(e) organic (1) **allow** hydrocarbon
fuel/alcohol/named alcohol (1) **allow** flammable [2]

5 (a) (i) P colourless, no smell (1) [1]

(ii) P pH 1–3 (1) [1]

(b) P fizzes/effervescence/bubbles (1)
lighted splint pops (1) **not** hydrogen [2]

(c) white (1) precipitate (1) [2]

(e) weak acid (1) ethanoic acid (2) [2]

(f) water (1) [1]

1 tests on solid **E**

(c) (i) white (1)
precipitate (1)
with excess dissolves/clears/colourless (1) [3]

(ii) white precipitate (1)
insoluble/no change (in excess) (1) [2]

(d) contains water/hydrated (1) [1]

(e) ammonia (1) not ammonium [1]

(f) nitrate (1)
hydrated salt (1)
not a sulfate (1) max [2] [2]

2 **(a)** **(i)** blue (1) [1]

(ii) blue (1) precipitate (1) [2]

(iii) blue precipitate (1)
deep / royal blue (1) solution (1) **or** precipitate dissolves [3]

(c) sulfuric acid (2) acid or sulfate only (1) [2]

[Total: 8]

3 **(a)** add dilute acid (1) fizz, no fizz (1) or correct chloride test [2]

(b) litmus paper/named indicator (1) turns blue (1) bleached (1) [3]

(c) sodium hydroxide/ammonia (solution) (1) green (precipitate) (1)
brown (precipitate) (1) [3]

4 tests on solid **S**

(c) **(i)** blue precipitate (1) [1]

(ii) blue (1) precipitate (1) [2]

dissolves/clears (1) deep/royal blue (1) [2]

(iii) white (1) precipitate (1) [2]

(f) **(i)** **V** is more reactive or converse (1) [1]

(ii) oxygen (1) [1]

(g) catalyst/transition metal/manganese oxide any two points (2)
V is a better catalyst = 2 [2]