ST ANDREW'S SECONDARY SCHOOL

NAME _____ TEACHING GROUP _____

Chemistry

PRACTICAL Theory Practice

Qualitative Analysis

1 A student investigates solution W.
The tests the student does on W, including the observations made, are shown in the table below.

Test	Description of test on solution W	Observations
1	Add aqueous sodium hydroxide to W.	Solution remains colourless.
2	Add dilute nitric acid, then add aqueous barium nitrate to W.	White precipitate forms.
3	Add dilute hydrochloric acid, then add aqueous silver nitrate to W.	White precipitate forms.
4	Flame test on W.	No colour is observed.

(a) The student correctly concludes that ammonia is produced in test **1**.
Describe what else the student must have done to reach this conclusion.

.....

.....

..... [2]

(b) Explain why the student cannot identify the anion in W from the observation in test **3**.

.....

..... [1]

(c) State how the tests and observations confirm that W does **not** contain sodium ions.

.....

..... [2]

(d) Identify the cation and anion in W.

cation ..... anion ..... [2]

2 Solid X is a shiny grey solid.
The tests the student does on X, including the observations made, are shown in the table below.

Test	Description of test on solid X	Observations
1	Add excess dilute acid to X in a test-tube. Effervescence is observed.	Solid disappears, solution remains colourless and becomes warmer.
2	Add dilute nitric acid, then add aqueous silver nitrate to a small portion of the solution from test **1**.	Solution remains colourless.
3	Add dilute nitric acid, then add aqueous barium nitrate to a small portion of the solution from test **1**.	White precipitate forms.

(a) Predict the identity of the gas evolved in the effervescence observed.
Describe how the student confirms the identity of this gas.

.....

.....

..... [3]

(b) The observations for test **1** are incomplete.
State one **other** observation that the student makes for test **1**.

..... [1]

(c) Propose **two** conclusions for test **1** using the observations shown in the table.

.....

..... [2]

(d) Give the conclusion you can make from

(i) test **2**.

..... [1]

(ii) test **3**.

..... [1]

(e) Identify the acid used in test **1**. ..... [1]

(f) Suggest the identity of solid X. ..... [1]

3 The following table shows the tests a student did on substance V and the conclusions made from the observations. Complete the table by describing these observations and suggest the test and observation which led to the conclusion in test **4**.

Tests	**Observations**	**Conclusion**
1 V was dissolved in water and the solution divided into three parts for tests **2**, **3** and **4**.		V contains the ion of a transition metal.
2(a) To the first part, aqueous sodium hydroxide was added until a change was seen. **2(b)** An excess of aqueous sodium hydroxide was added to the mixture from **2(a)**.		V may contain Cu^{2+} ions.
3(a) To the second part, aqueous ammonia was added until a change was seen. **3(b)** An excess of aqueous ammonia was added to the mixture from **3(a)**.		The presence of Cu^{2+} ions in V is confirmed.
4		V contains Cl^-.

[5]

Formula for substance V: ..... [1]

4 Substance Z is a reducing agent. The table below shows the tests a student did on Z. Complete the table below. In cases where a colour change is involved, both initial and final colours should be stated.

Tests	**Observations**	**Conclusion**
1 Z was dissolved in water and the resulting solution divided into two parts for tests **2** and **3**.	A coloured solution was obtained.	
2 To the first part, a few drops of acidified potassium permanganate were added.		Z is a reducing agent.
3 To the second part, a few drops of acidified potassium iodide were added.		Z is confirmed to be a reducing agent.

[3]

5 Compound G contains two ions. Complete the table below.

Tests	Observations	Conclusion
1 G was dissolved in water and the solution divided into three parts for tests **2**, **3** and **4**.		G is unlikely a compound of a transition metal.
2(a) To the first part, aqueous sodium hydroxide was added until a change was seen. **2(b)** An excess of aqueous sodium hydroxide was added to the mixture from **2(a)**.	A white precipitate is formed. The white precipitate formed dissolves.	G may contain the ions Al^{3+} or ..... or .....
3(a) To the second part, aqueous ammonia was added until a change was seen. **3(b)** An excess of aqueous ammonia was added to the mixture from **3(a)**.		The presence of Al^{3+} in G is confirmed.
4		G contains NO_3^-.

[5]

Formula for compound G: ..... [1]

6 The following table shows the tests a student did on substance X. Complete the table.

Tests	Observations	Conclusion
1(a) X was dissolved in dilute nitric acid and the solution divided into two parts for tests **2** and **3**. **1(b)** The gas evolved was tested with		A gas was produced. X is a compound of a transition metal. X contains CO_3^{2-}.
2(a) To the first part, aqueous sodium hydroxide was added until a change was seen. **2(b)** An excess of aqueous sodium hydroxide was added to the mixture from **2(a)**.		X may contain Fe^{2+} ions.
3(a) To the second part, aqueous ammonia was added until a change was seen. **3(b)** An excess of aqueous ammonia was added to the mixture from **3(a)**.		X contains Fe^{2+} ions.

[4]

Formula for substance X: ..... [1]

7 Compound M contains three ions. Complete the table below.

Tests	Observations	Conclusion
1 M was dissolved in water and the solution divided into two parts for tests **2** and **3**.	A coloured solution is formed.	
2(a) To the first part, aqueous sodium hydroxide was added until a change was seen. **2(b)** An excess of aqueous sodium hydroxide was added to the mixture from **2(a)**. **2(c)** The mixture obtained is heated.		M contains Fe^{2+} ions. M contains Fe^{2+} ions. M contains NH_4^+ ions.
3		M contains SO_4^{2-} ions.

[4]

8 A student is given three colourless liquids, A, B and C. He knows that the liquids are hexene, ethanol and ethanoic acid. To identify A, B and C, he does some tests by adding the reagents in the table to each liquid.

Test	Observations		
	A	B	C
Add aqueous bromine.		The mixture turns from brown to colourless.	The mixture remains brown.
Add solid calcium carbonate.	No visible change.	No visible change.	
Add dilute sulfuric acid and a few drops of aqueous potassium permanganate.		The mixture turns from purple to colourless.	The mixture remains purple.

(a) Complete the table above. [3]

(b) Deduce the identity of liquids A, B and C.

A .....

B .....

C ..... [3]

(c) Suggest a reason for adding dilute sulfuric acid in the test with aqueous potassium permanganate.

..... [1]

NOTES FOR QUALITATIVE ANALYSIS

Test 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.
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 with dilute nitric acid, then add aqueous barium nitrate	white ppt.

Test 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.
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

Test for gases

gas	test and test result
ammonia (NH_3)	turns damp red litmus paper blue
carbon dioxide (CO_2)	gives 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

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NAME ANSWERS TEACHING GROUP

Chemistry

PRACTICAL Theory Practice

Qualitative Analysis

1 **(a)** To reach the correct conclusion of ammonia produced in test 1, the following must also be done by the student:

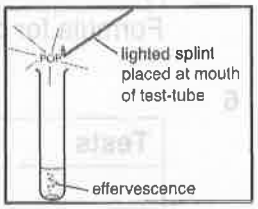
- heat the mixture formed after the addition of NaOH to W.
- use damp red litmus paper to test for the gas produced.
- observe the colour change of the damp red litmus paper to blue in order to confirm the identity of the gas as NH_3.

(b) HCl contains Cl^- that resulted in the white ppt. formed in the reaction with $AgNO_3$.

(c) Test 4.
Na^+ would produce a yellow flame (metal cations produce coloured flames). Since no colour flame is observed, hence W does not contain Na^+.

(d) cation: NH_4^+ (based on test 1) anion: SO_4^{2-} (based on test 2)

2 **(a)** Hydrogen gas. (X is a metal based on its shiny grey appearance)
Test the gas evolved with a lighted splint placed at the mouth of the test-tube.
Lighted splint extinguishes with a 'pop' sound.



(b) Bubbles of a colourless gas evolved.

(c) X is not a transition metal. (solution remains colourless)
Reaction is exothermic. (solution becomes warmer)

(d) **(i)** There are no halide ions in the solution. (Ag^+ forms ppt. with all halides, not just Cl^-)

(ii) SO_4^{2-} is present in the solution.

(e) Sulfuric acid, H_2SO_4.

(f) Magnesium or Zinc (not Ca as white ppt would be obtained in test 1; not Al as oxide layer of Al prevents reaction with acids; not Group I metals as involved vigorous reactions will be too dangerous to perform safely in the lab).

3

Tests	**Observations**	**Conclusion**
1 V was dissolved in water and the solution divided into three parts for tests **2**, **3** and **4**.	*A blue solution is formed.*	V contains the Ion of a transition metal.
2(a) To the first part, aqueous sodium hydroxide was added until a change was seen. **2(b)** An excess of aqueous sodium hydroxide was added to the mixture from **2(a)**.	*Light blue ppt. formed, insoluble in excess aq NaOH.*	V may contain Cu^{2+} ions.
3(a) To the second part, aqueous ammonia was added until a change was seen. **3(b)** An excess of aqueous ammonia was added to the mixture from **3(a)**.	*Light blue ppt. formed, soluble in excess aq NH_3 giving a dark blue solution.*	The presence of Cu^{2+} ions in V is confirmed.
4 *To the third part, dilute nitric acid was added followed by aqueous silver nitrate.*	*White ppt. formed.*	V contains Cl^-.

Formula for substance V: **$CuCl_2$**

4

Tests	Observations	Conclusion
1 Z was dissolved in water and the resulting solution divided into two parts for tests **2** and **3**.	A coloured solution was obtained.	*Z is an aqueous salt that contains the ions of a transition metal.*
2 To the first part, a few drops of acidified potassium permanganate were added.	*Purple solution decolourises.*	Z is a reducing agent.
3 To the second part, a few drops of acidified potassium iodide were added.	*No observable change.*	Z is confirmed to be a reducing agent.

5

Tests	Observations	Conclusion
1 G was dissolved in water and the solution divided into three parts for tests **2**, **3** and **4**.	*A colourless solution is formed.*	G is unlikely a compound of a transition metal.
2(a) To the first part, aqueous sodium hydroxide was added until a change was seen. **2(b)** An excess of aqueous sodium hydroxide was added to the mixture from **2(a)**.	A white precipitate is formed. The white precipitate formed dissolves.	G may contain the ions Al^{3+} or Zn^{2+} or Pb^{2+}.
3(a) To the second part, aqueous ammonia was added until a change was seen. **3(b)** An excess of aqueous ammonia was added to the mixture from **3(a)**.	*White ppt. formed, insoluble in excess aq NH_3.*	The presence of Al^{3+} in G is confirmed.
4 *To the third part, aqueous NaOH was added followed by Al foil before the mixture was heated gently. Gas evolved was tested with a piece of damp red litmus paper.*	*Gas evolved turns damp red litmus paper blue. Gas is NH_3.*	G contains NO_3^-.

Formula for compound G: **$Al(NO_3)_3$**

6

Tests	Observations	Conclusion
1(a) X was dissolved in dilute nitric acid and the solution divided into two parts for tests **2** and **3**. **1(b)** The gas evolved was tested with *limewater, $Ca(OH)_2$.*	*Effervescence observed with a pale green solution formed.* *Gas evolved gives white ppt. when bubbled into limewater. Gas is CO_2.*	A gas was produced. X is a compound of a transition metal. X contains CO_3^{2-}.
2(a) To the first part, aqueous sodium hydroxide was added until a change was seen. **2(b)** An excess of aqueous sodium hydroxide was added to the mixture from **2(a)**.	*Green ppt. formed, insoluble in excess NaOH. Top layer of green ppt. turns orange upon standing.*	X may contain Fe^{2+} ions.
3(a) To the second part, aqueous ammonia was added until a change was seen. **3(b)** An excess of aqueous ammonia was added to the mixture from **3(a)**.	*Green ppt. formed, insoluble in excess NaOH. Top layer of green ppt. turns orange upon standing.*	X contains Fe^{2+} ions.

Formula for substance X: **$FeCO_3$**

7

Tests	Observations	Conclusion
1 M was dissolved in water and the solution divided into two parts for tests **2** and **3**.	A coloured solution is formed.	*M contains the ion of a transition metal.*
2(a) To the first part, aqueous sodium hydroxide was added until a change was seen. **2(b)** An excess of aqueous sodium hydroxide was added to the mixture from **2(a)**. **2(c)** The mixture obtained is heated.	*Green ppt. formed, insoluble in excess NaOH. A pungent gas is produced. Gas turns damp red litmus paper blue. Gas is NH_3.*	M contains Fe^{2+} ions. M contains Fe^{2+} ions. M contains NH_4^+ ions.
3 *To the second part, dilute nitric acid was added followed by aqueous barium nitrate.*	*White ppt. formed.*	M contains SO_4^{2-} ions.

8 (a)

Test	Observations		
	A	**B**	**C**
Add aqueous bromine.	*The mixture remains brown.*	The mixture turns from brown to colourless.	The mixture remains brown.
Add solid calcium carbonate.	No visible change.	No visible change.	*Effervescence observed. Solid dissolves in colourless solution and becomes warmer.*
Add dilute sulfuric acid and a few drops of aqueous potassium permanganate.	*The purple colour mixture is decolourised.*	The mixture turns from purple to colourless.	The mixture remains purple.

(b) A **Ethanol**
B **Hexene**
C **Ethanoic acid**

(c) H_2SO_4 is added in the test to catalyse the reaction. (oxidation by $KMnO_4$)