

# GCSE Chemistry (9 – 1)

## Ion Analysis

Name: .....

Group: .....

### Instructions

- Read each question carefully before you begin to answer it.
- Use black ink or black ball-point pen for your answers.
- Fill in the boxes at the top of this page with your name and group.
- Attempt to answer every question in the booklet.
- Answer the questions in the spaces provided – there may be more space than you need in some answer spaces.
- Calculators may be used for this booklet.
- For any calculations, you **must** show all your working.
- Any and all drawings or graphs should be completed in pencil.



| For markers use |      |
|-----------------|------|
| Question        | Mark |
| 1               | /6   |
| 2               | /10  |
| 3               | /10  |
| 4               | /15  |
| 5               | /12  |
| 6               | /10  |
| 7               | /9   |
| 8               | /6   |
| Total           | /78  |
| %               |      |
| Grade           |      |

### Information

- The maximum mark for this paper is 78 marks.
- The marks for each question are shown in brackets.
- Please be aware that good English and clear presentation are required in your answers.



1. Ion analysis is essentially chemical detective work where we use specific tests to uncover the identity of unknown compounds by revealing the unique positive and negative ions within the substance.

Circle the letter of the correct answer for each of the following questions.

- a) A student carries out a flame test on an unknown solid. The flame turns a crimson colour. Which ion is present in the solid?

| A                            | B                           | C                         | D                          |
|------------------------------|-----------------------------|---------------------------|----------------------------|
| Calcium ( $\text{Ca}^{2+}$ ) | Copper ( $\text{Cu}^{2+}$ ) | Lithium ( $\text{Li}^+$ ) | Potassium ( $\text{K}^+$ ) |
| (1 mark)                     |                             |                           |                            |

- b) An aqueous sample of an unknown material is heated with aqueous sodium hydroxide and a few pieces of calcium. A gas is given off which turns damp red litmus paper **blue**.

5 cm<sup>3</sup> of sodium hydroxide solution is added to a second aqueous sample of X.

A **green** precipitate is then seen. Use this information to identify the unknown material.

| A                | B                | C                 | D              |
|------------------|------------------|-------------------|----------------|
| iron(II) nitrate | iron(II) sulfate | iron(II) chloride | iron(II) oxide |
| (1 mark)         |                  |                   |                |

- c) Sodium hydroxide solution is added to a solution containing an unknown metal ion. A **white** precipitate is formed.

When excess sodium hydroxide solution is added, the precipitate **dissolves** to form a colourless solution.

What is the identity of the metal ion?

| A                            | B                              | C                             | D                              |
|------------------------------|--------------------------------|-------------------------------|--------------------------------|
| Calcium ( $\text{Ca}^{2+}$ ) | Magnesium ( $\text{Mg}^{2+}$ ) | iron(II) ( $\text{Fe}^{2+}$ ) | Aluminium ( $\text{Al}^{3+}$ ) |
| (1 mark)                     |                                |                               |                                |

- d) Which two chemicals are used to test for the presence of **sulfate ions**,  $\text{SO}_4^{2-}$ ?

- A Dilute hydrochloric acid and barium chloride solution.
- B Dilute nitric acid and silver nitrate solution.
- C Dilute sulfuric acid and lime water.
- D Dilute hydrochloric acid and sodium hydroxide solution.

(1 mark)

e) A mixture containing two different anions was tested and the results are shown in the table below.

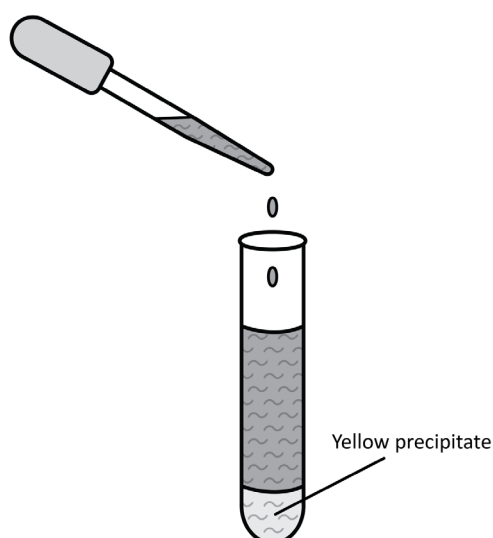
| Chemical test                                                | Result                                              |
|--------------------------------------------------------------|-----------------------------------------------------|
| Dilute nitric acid added                                     | Effervescence of a gas which turned limewater milky |
| Dilute nitric acid added, followed by aqueous silver nitrate | Cream precipitate formed                            |

Which **two** anions were present?

- A Carbonate and chloride.
- B Carbonate and bromide.
- C Sulfate and chloride.
- D Sulfate and bromide.

(1 mark)

f) A student observes a **yellow precipitate** forming in a test tube during an ion analysis test. Which chemical test was likely used on the sample, and which ion caused this result?



- A Silver nitrate ( $\text{AgNO}_3$ ) testing for chloride ions ( $\text{Cl}^-$ )
- B Silver nitrate ( $\text{AgNO}_3$ ) testing for iodide ions ( $\text{I}^-$ )
- C Barium chloride ( $\text{BaCl}_2$ ) testing for sulfate ions ( $\text{SO}_4^{2-}$ )
- D Silver nitrate ( $\text{AgNO}_3$ ) testing for bromide ions ( $\text{Br}^-$ )

(1 mark)

(Total for Question 1 is 6 marks)

2. A student carries out a flame test on a solid compound and observes a green-blue flame. She then adds dilute sulfuric acid to a fresh sample of the solid. Rapid fizzing is observed, and the gas produced causes limewater to turn milky.

- a) State which anion is present in the compound and explain how the observation with limewater confirms this.

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**(2 marks)**

- b) The student adds aqueous sodium hydroxide to the reaction mixture. A blue solid forms which does not dissolve. State the chemical name or the formula of this blue solid.

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**(1 mark)**

- c) When barium chloride is added to a solution containing sulfate ions, an insoluble white solid is created. Write the ionic equation for this specific precipitation reaction, including the correct state symbols.

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**(3 marks)**

- d) An unknown sample is suspected to contain a halide ion. Plan a chemical test to identify which specific halide (chloride, bromide, or iodide) is present.

Your answer should include:

- The names of the chemical reagents used.
- The observation expected for each of the three ions.

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**(4 marks)**

(Total for Question 2 is 10 marks)

3. A lab technician analyses a sample containing a mixture of sodium ions and potassium ions. When performing a standard flame test, only a yellow flame is visible.
- a) Explain why a simple flame test might fail to detect the potassium ions, and suggest an instrumental method that could define exactly which metal ions are present.

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(2 marks)

- b) The technician then moved on to trying to identify three unknown salt solutions labelled **solution X**, **solution Y**, and **solution Z**.

He performs two specific tests on a separate sample of each solution:

**Test A:** Addition of dilute nitric acid followed by silver nitrate solution.

**Test B:** Addition of sodium hydroxide solution, followed by heating the mixture.

His results and subsequent hypotheses are recorded in the table below.

| Salt Solution | Observation for Test A | Observation for Test B                                | Technician's Conclusion |
|---------------|------------------------|-------------------------------------------------------|-------------------------|
| <b>X</b>      | White precipitate      | No precipitate formed.<br>Solution remains colourless | Ammonium Chloride       |
| <b>Y</b>      | White precipitate      | White precipitate formed                              | Aluminium Chloride      |
| <b>Z</b>      | No visible change      | Dark green precipitate formed                         | Iron(II) Sulfate        |

Evaluate the technician's conclusion.

In your answer, you should:

- Explain which parts of the hypotheses are supported by the observations.
- Identify which parts are not fully proven.
- Describe the specific further tests needed to confirm the identity of each substance.

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**(6 marks)**

c) Explain why the addition of acid is essential for a valid conclusion.

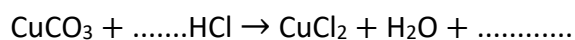
**(2 marks)**

Page | 5

4. Copper is a useful metal that can be used to make salts.

A student prepares a sample of copper(II) chloride by reacting copper carbonate with dilute hydrochloric acid.

- a) Complete and balance the equation for this reaction.



**(2 marks)**

- b) Calculate the percentage by mass of copper in copper(II) chloride,  $\text{CuCl}_2$ .

Relative atomic masses ( $A_r$ ): Cl = 35.5 Cu = 63.5

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Percentage by mass = ..... %

**(3 marks)**

- c) A student analyses another solution of copper(II) chloride.

Describe chemical tests to show the presence of copper(II) ions and chloride ions in the solution.

Give the expected positive result for each test.

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**(4 marks)**

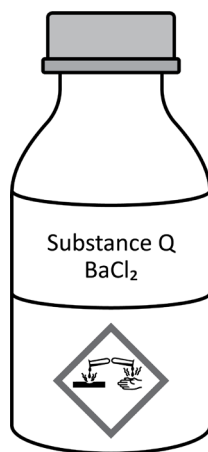
Describe how phytomining and bioleaching are used to extract copper, and evaluate the advantages of using these methods compared to traditional mining.

- A description of the phytomining process.
- A description of the bioleaching process.
- An advantage and disadvantage of using each of these methods.

[illegible]

(Total for Question 4 is 15 marks)

5. The figure below shows a glass bottle containing substance Q, Barium chloride.



A student adds dilute sulfuric acid,  $\text{H}_2\text{SO}_4$ , to a solution of barium chloride,  $\text{BaCl}_2$ .  
A white precipitate is formed.

- a) Give the name of the white precipitate formed.

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(1 mark)

- b) Write the **ionic equation** for the formation of this white precipitate.  
Include state symbols in your equation.

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(3 marks)

A student uses solution Q to test an unknown solid for sulfate ions.  
The student uses the following method:

**Step 1:** dissolve a small amount of the solid being tested in water.

**Step 2:** add some dilute sulfuric acid.

**Step 3:** add a few drops of solution Q.

**Step 4:** observe whether or not a white precipitate forms.

The method the student used to determine whether the solid contains sulfate ions will **not** work.

- c) Explain a change that needs to be made to step 2 to allow this method to work.

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(2 marks)

A student analyses a sample of a Group 1 carbonate,  $X_2CO_3$ .

The student determines that the relative formula mass of the substance is 230.

- d) Calculate the relative atomic mass of X and suggest the identity of the element.

(Relative atomic masses: C = 12, O = 16)

Identity of element X = .....

**(3 marks)**

The student dissolves 11.5 g of the carbonate,  $X_2CO_3$ , in distilled water to make 500 cm<sup>3</sup> of solution.

- e) Calculate the concentration of this solution in mol/dm<sup>3</sup>.

Concentration = ..... mol/dm<sup>3</sup>

**(3 marks)**

(Total for Question 5 is 12 marks)

6. A student is given a sample of a common fertiliser.  
The student is told that the fertiliser is ammonium sulfate,  $(\text{NH}_4)_2\text{SO}_4$ .

The student dissolves the solid in distilled water to make a solution.

- a) Give the formula for an ammonium ion.

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**(1 mark)**

- b) Describe a chemical test to show that the solution contains ammonium ions.

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**(3 marks)**

- c) Describe a chemical test to show that the solution contains sulfate ions.

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**(3 marks)**

- d) Write the ionic equation, including state symbols, for the reaction that occurs during the test for sulfate ions.

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**(3 marks)**

(Total for Question 6 is 10 marks)

7. A chemist investigates a sample of a powder used in fireworks.  
The figure below shows some fireworks exploding.



The powder is known to be a mixture of two different salts.

The chemist performs a standard flame test on the solid mixture. A bright **yellow** flame is observed.

The chemist concludes that the mixture contains sodium ions, but suspects another metal ion might also be present.

- a) Explain why the flame test might not identify the second metal ion in the mixture.

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(1 mark)

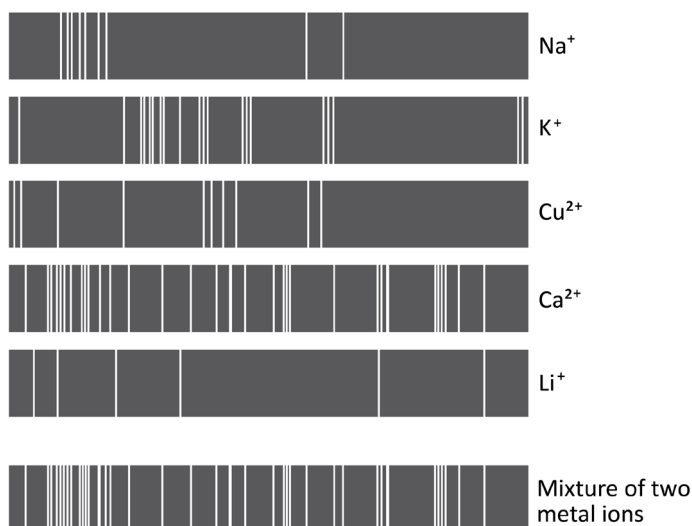
- b) The chemist dissolves the mixture in distilled water and adds sodium hydroxide solution.  
A white precipitate is formed. Suggest **two** metal ions that could cause this result.

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(2 marks)

To identify the metal ions definitively, the chemist uses Flame Emission Spectroscopy.  
The results are shown in the figure below.



c) Use the figure to identify the two metal ions that are present in the mixture.

**Explain** how you reached your conclusion.

Ion 1: .....

Ion 2: .....

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**(4 marks)**

d) Compare flame emission spectroscopy with the standard manual flame test.

Give two reasons why flame emission spectroscopy is a better method for this specific analysis.

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**(2 marks)**

(Total for Question 7 is 9 marks)

8. A student is provided with three colourless solutions in beakers labelled A, B, and C. The student is told that the solutions are:

Potassium chloride

Potassium bromide

Potassium iodide

However, the student does not know which solution is in which beaker.

Describe a chemical test the student could carry out to identify the halide ion in each beaker.

This image shows a full page of white paper with horizontal dotted lines. The lines are evenly spaced and run across the width of the page, providing a guide for handwriting practice. There are no margins, text, or other markings on the page.

**(6 marks)**

(Total for Question 8 is 6 marks)