Ion Analysis Notes

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Ion analysis involves chemical tests to identify which cations (positive ions) and which anions (negative ions) are present in a sample. These tests are commonly used in qualitative analysis to detect specific ions.

Qualitative analysis: is a series of tests that can be used to identify whether a specific substance is present or absent. It doesn't tell us how much of a substance is there. It just tells us what's present or absent in our sample.

Just to quickly remind ourselves, what's an ion?

An ion? an ion is an electrically charged particle that is formed by the loss or gain of one or more electrons.

How do we identify the ions that are in a substance? We do a chemical reaction with the substance and look for any precipitate at the end of the reaction.

A precipitate: a solid formed by the reaction of two solutions.

Tests for Cations – Sodium Hydroxide Test

Test: add a few cm^3 of sodium hydroxide (NaOH) to the substance being tested.

Result: take note of the colour of the precipitate if one forms. The table below shows the precipitates that we would expect for the metal ions.

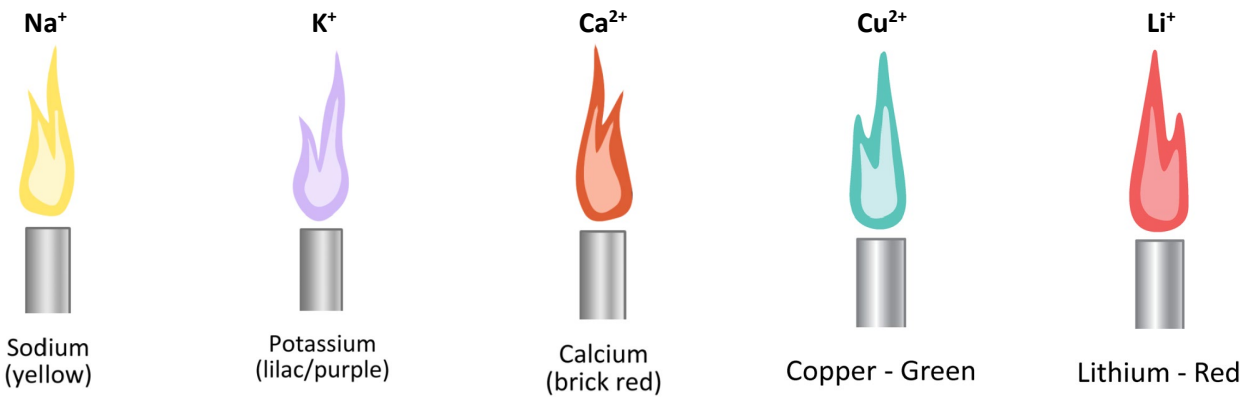
Cation	Observation with NaOH (aq)	Observation with excess NaOH (aq)
Cu^{2+}	**Blue precipitate**	Blue precipitate remains
Fe^{2+}	**Green precipitate**	Green precipitate remains
Fe^{3+}	**Brown/rust precipitate**	Brown precipitate remains
Ca^{2+}	**White precipitate**	White precipitate remains
Al^{3+}	**White precipitate**	Precipitate re-dissolves
Mg^{2+}	**White precipitate**	White precipitate remains

The Flame Tests

Everyone's favourite tests 😊 When an atom is heated strongly the electrons are excited from one shell to another. As they move, they give out energy in the form of light. This light can then be used to identify the cation.

Test: dip the test rod into a solution. It is then placed in a hot Bunsen flame and the colour of the flame noted.
Note: the test wire is a **nichrome wire** or it can also be a **platinum wire**.

Result: the figure below shows the ions and their positive result.



Exam note: it is not uncommon to get questions asking either "how the test rod should be cleaned?" or "why not cleaning the test rod will cause issues?" Let's look at each of these 😊

Q. How should the test rod be cleaned?
A. The flame test rod or wire should first be cleaned by dipping it into concentrated hydrochloric acid solution, rinsing it with distilled water then heating in a flame until no colour can be seen.

Q. Why will not cleaning the test rod cause issues?
A. It will be more difficult to see the individual colours. Or it will mask the colours.

Tests for Anions

Test for Carbonate Ions (CO_3^{2-})

Test: Add a few cm^3 of nitric acid to the unknown compound (usually as a solution).

Result: If there is effervescence (fizzing) test the gas with limewater. If it turns cloudy then the anion is CO_3^{2-}.

Test for Sulfate Ions (SO_4^{2-})

Test: First add nitric acid to check CO_3^{2-} is not present (no fizzing), then… add a few drops of barium chloride solution.

Result: A thick white precipitate (barium sulfate) shows that sulfate (SO_4^{2-}) ions are present**.**
The ionic equation for this reaction is:

$$Ba^{2+}\,(aq) + SO_4^{2-}\,(aq) \rightarrow BaSO_4\,(s)$$

Exam note: In both examples above we have used nitric acid.

We cannot use sulfuric acid because they contain sulfate which would interfere with the test for sulfate ions and would give us incorrect results.

When we do a Silver Nitrate test we must use Nitric acid. So… we only use Nitric acid in the examples as that means there is only one acid to learn. 😊

Test for Halide Ions (Cl^-, Br^-, I^-)

Test: add a few cm^3 of nitric acid to show that CO_3^{2-} is not present (no fizzing) then add a few drops of silver nitrate solution ($AgNO_3(aq)$)

Result: the table below shows the ions and their positive result.

Halide ion	Observation with $AgNO_3$ (aq)
Cl^-	**White precipitate**
Br^-	**Cream precipitate**
I^-	**Yellow precipitate**

Instrumental Methods

Instrumental methods are advanced techniques of analysis used to detect and identify elements and compounds.
What are the advantages of using instrumental methods rather than chemical tests?

1. Accuracy – they give us precise and reliable results. They also reduce human error compared to chemical tests.
2. Sensitivity – instrumental methods are able to detect very small amounts of a substance.
3. Speed – instrumental methods are much faster than chemical tests. This allows us to do a lot of tests quickly.

Examples of instrumental methods are:

1. Flame Emission Spectroscopy – this identifies metal ions by analysing the light emitted in a flame.
2. Mass Spectrometry – this finds the masses of particles in a sample and compares the values we get to known values to identify elements and compounds.