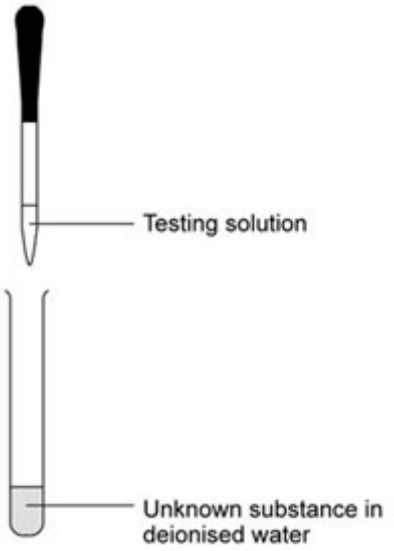
Testing salts for anions and cations – student sheet

Introduction

Chemists often have to identify the composition of unknown substances. This experiment involves identifying the cations and anions in various salt solutions.



This experiment should take around 1-2 hours.

Equipment

Apparatus

- Eye protection
- Test tubes

Chemicals

Access to:

- Full range indicator paper
- Ammonia solution, 2 mol dm^{-3}
- Sodium hydroxide solution, 0.4 mol dm^{-3}
- Hydrochloric acid solution, 0.4 mol dm^{-3}
- Barium chloride solution, 0.1 mol dm^{-3}
- Limewater solution, 0.02 mol dm^{-3}
- Nitric acid, 0.4 mol dm^{-3}
- Silver nitrate solution, 0.1 mol dm^{-3}
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Unknown substances labelled A, B, C …each might contain one of the following anions and one of the following cations:

Anions - OH^-, SO_4^{2-}, CO_3^{2-}, Cl^-, Br^-, I^-, NO_3^-
Cations - H^+, Ca^{2+}, Cu^{2+}, Fe^{3+}, Fe^{2+}, NH_4^+

A sensible selection might be:

- Copper chloride (toxic if swallowed, causes skin irritation and eye damage)
- Potassium carbonate (harmful if swallowed, skin/eye irritant)
- Potassium iodide (skin/eye irritant)
- Copper(II) sulfate (harmful if swallowed, skin/eye/respiratory irritant)
- Iron(III) chloride (harmful if swallowed, skin Irritant, causes serious eye damage)
- Iron(II) sulfate (harmful if swallowed, skin/eye irritant)
- Lead nitrate (reproductive toxin, causes serious eye damage, harmful if swallowed or inhaled, possible carcinogen and skin sensitiser)

Health, safety and technical notes

- Read our standard health and safety guidance here https://rsc.li/3j03kxu
- Always wear eye protection.
- Prepare dilute solutions in a fume cupboard.
- Ammonia solution is corrosive, causing burns, and gives off ammonia vapour which irritates the eyes, lungs and respiratory system. See CLEAPSS Hazcard HC006
- Sodium hydroxide is corrosive, causing burns and is extremely dangerous to the eyes. See CLEAPSS Hazcard HC091a
- Hydrochloric acid is corrosive, causing burns. It also gives off choking fumes. See CLEAPSS Hazcard HC047a
- Barium chloride is harmful by inhalation and toxic if swallowed. See CLEAPSS Hazcard HC010a
- Nitric acid is corrosive, causing burns. It also gives off toxic fumes. See CLEAPSS Hazcard HC067
- Silver nitrate is corrosive to skin and eyes and an oxidising agent. The 0.1 mol dm-3 solution is of Low hazard. See CLEAPSS Hazcard HC087.

Procedure

1. Dissolve the unknown substance in deionised water. 5–10 cm^3 of solution may be needed.
2. Using the analysis table, test small aliquots (portions).
3. Repeat for the other unknown substances.
4. Record your findings.

Test	Anion	Test and observe
A Silver nitrate followed by ammonia solution	Chloride (Cl^-)	Add a few drops of dilute nitric acid (Irritant) followed by a few drops of silver nitrate solution. A white precipitate of silver chloride is formed. The precipitate is soluble in ammonia solution.
	Bromide (Br^-)	Add a few drops of dilute nitric acid (Irritant) followed by a few drops of silver nitrate solution. A pale yellow precipitate of silver bromide is formed. The precipitate is slightly soluble in ammonia solution.

	Iodide (I^-)	Add a few drops of dilute nitric acid (irritant) followed by a few drops of silver nitrate solution. A yellow precipitate of silver iodide is formed. It is insoluble in ammonia solution.
B Barium chloride	Sulfate (SO_4^{2-})	Add a few drops of barium chloride solution followed by a few drops of dilute hydrochloric acid. A white precipitate of barium sulfate is formed.
C Hydrochloric acid	Carbonate (CO_3^{2-})	Add dilute hydrochloric acid to the solution (or add it to the solid). Bubbles of carbon dioxide are given off.

Cation	**DAdd sodium hydroxide solution**	**EAdd ammonia solution**
Ammonium ($NH_4^+(aq)$)	Warm carefully. Do not allow to spit. Ammonia (alkali gas) is given off	
Copper ($Cu^{2+}(aq)$)	Blue (jelly-like) precipitate of $Cu(OH)_2(s)$	Blue jelly like precipitate dissolves in excess ammonia to form a deep blue solution.
Iron(II) ($Fe^{2+}(aq)$)	Green gelatinous precipitate of $Fe(OH)_2(s)$	Green gelatinous precipitate
Iron(III), ($Fe^{3+}(aq)$)	Rust-brown gelatinous precipitate of $Fe(OH)_3(s)$	Rust brown gelatinous precipitate
Lead(II), ($Pb^{2+}(aq)$)	White precipitate $Pb(OH)_2(s)$ dissolves in excess NaOH(aq)	White precipitate, $Pb(OH)_2$
Zinc ($Zn^{2+}(aq)$)	White precipitate, $Zn(OH)_2(s)$	White precipitate, $Zn(OH)_2(s)$ dissolves in excess $NH_3(aq)$
Aluminium ($Al^{3+}(aq)$)	Colourless precipitate, $Al(OH)_3(s)$	Colourless precipitate, $Al(OH)_3(s)$

Flame Test

1. Slightly open the air hole of the Bunsen burner.
2. Heat a piece of nichrome wire in a Bunsen flame until the flame is no longer coloured.
3. Dip the loop at the end of the wire into some water.
4. Dip the loop into an unknown salt.
5. Hold the wire in the edge of the flame.
6. Record the colour and identify the cation using the table provided.

Metal	Colour of flame
Barium	Apple-green
Calcium	Brick-red
Copper	Green with blue streaks
Lithium	Crimson
Potassium	Lilac
sodium	Yellow

Questions

1. Write word and ionic equations for those reactions that give a positive result.