Identifying ions

Part 1: Flame tests for metal ions

Equipment (per group)

Set this up as 6 stations (or as many as you can safely have) for students to move around.

At each station you will need

- 1 x Bunsen burner
- 1 x heat resistant mat
- 1 x boiling tube rack
- boiling tube containing a salt solution or distilled water and soaked wooden splints
- beaker with water (for disposal of used splints)
- matches and splint

Safety equipment: safety spectacles

Preparation

Thoroughly soak some wooden splints in distilled water for 24 hours prior to the experiment.

You will need the following chemicals. Each boiling tube will need 25 cm^3 of solution.

- 0.5 mol dm^{-3} lithium chloride solution
- 0.5 mol dm^{-3} sodium chloride solution
- 0.5 mol dm^{-3} potassium chloride solution
- 0.5 mol dm^{-3} calcium chloride solution
- 0.5 mol dm^{-3} copper(II) chloride solution
- Distilled water

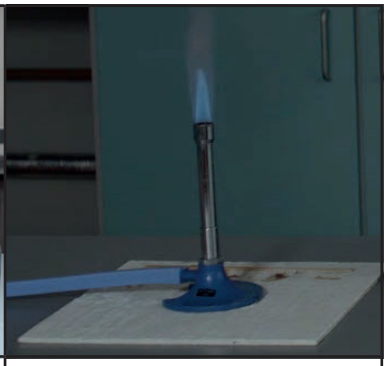
Half fill a labelled boiling tube with each salt solution. For purposes of a control, one boiling tube should contain distilled water.

Pre-soak the wooden splints in water for 24 hours and place into each boiling tube containing the prepared solutions for about 1 hour before the start of the lesson. Do not leave for longer as the solution will 'wick up' the splint and evaporate and it will become a risk to students who will be touching the solutions.

Note: the chloride salts give the best results but other salts such as sulfates or nitrates can be used if needed. Lithium iodide and potassium iodide may also be used for lithium and potassium ions.

Equipment set-up and tips

Soak splints in water for 24 hours, then in each solution for one hour before the lesson.



Dim the light in the room, if possible.

Use a Bunsen burner blue flame.

Safety

Read our standard health & safety guidance and carry out a risk assessment before running any live practical.

Refer to SSERC/CLEAPSS Hazcards and recipe sheets.

Hazard classification may vary depending on supplier.

Chemical supplied for the practical	Preparation
Lithium chloride solution – 0.5 mol dm^{-3} LiCl (aq) Currently not classified as hazardous	Lithium chloride solid LiCl (s) MW = 42.39 g mol^{-1}  **WARNING** Harmful if swallowed Causes skin irritation Causes eye irritation
Sodium chloride solution – 0.5 mol dm^{-3} NaCl (aq)	Sodium chloride solid NaCl (s) MW = 58.44 g mol^{-1} Currently not classified as hazardous
Potassium chloride solution – 0.5 mol dm^{-3} KCl (aq) Currently not classified as hazardous	Potassium chloride solid KCl (s) MW = 74.55 g mol^{-1} Currently not classified as hazardous
Calcium chloride solution – 0.5 mol dm^{-3}	Calcium chloride-6-water solid
$CaCl_2$ (aq) Currently not classified as hazardous	$CaCl_2.6H_2O$ (s) MW = 219.08 g mol^{-1} Currently not classified as hazardous **Do not use anhydrous calcium chloride to make solutions; the reaction with water is highly exothermic and the water may boil.**
Copper(II) chloride solution – 0.5 mol dm^{-3} $CuCl_2$ (aq) Currently not classified as hazardous	Hydrated copper(II) chloride solid $CuCl_2.2H_2O$ (s) MW = 170.48 g mol^{-1}  **WARNING** Harmful if swallowed Causes skin irritation Causes eye irritation Very toxic to aquatic life with long lasting effects

Disposal

Place used splints in the normal waste.

Salt solutions can be re-used for the same experiment unless contaminated; keep the solutions in separate bottles; contaminated solutions can be diluted further and poured down a foul-water drain.

Part 2: Metal hydroxide precipitate test

Equipment (per group)

- 1 x copy of the table or integrated instructions in a plastic wallet or laminated
- a set of salt solutions to be tested in small dropper bottles
- 1 x sodium hydroxide solution in a dropper bottle
- paper towel to wipe clean

Safety equipment: safety spectacles

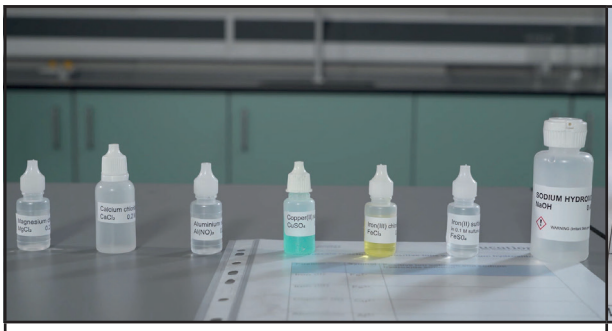
Preparation

The exact concentrations are not critical but should be less than 0.5 mol dm^{-3}.

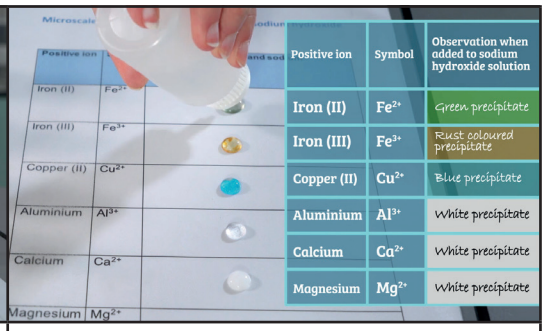
It is best to make up solutions in dropper bottles. Ideally one set of bottles per group of students. If dropper bottles are not available, use beakers and dropping pipettes.

- 0.4 mol dm^{-3} sodium hydroxide solution
- 0.2 mol dm^{-3} iron(II) sulfate(VI) solution made in 0.1 mol dm^{-3} sulfuric acid solution
- 0.2 mol dm^{-3} iron(III) nitrate solution
- 0.2 mol dm^{-3} copper(II) sulfate(VI) solution
- 0.2 mol dm^{-3} aluminium nitrate solution
- 0.2 mol dm^{-3} calcium chloride solution
- 0.2 mol dm^{-3} magnesium chloride solution

Equipment set-up and tips



This microscale version is easy to set up and quick to clean up.



The drops are placed onto sheet (in resources pack), laminated or in a plastic wallet.

Safety

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Refer to SSERC/CLEAPSS Hazcards and recipe sheets.

Hazard classification may vary depending on supplier.

Chemical supplied for the practical	Preparation
Sodium hydroxide solution – 0.4 mol dm^{-3} NaOH (aq)  **WARNING** Irritant (skin, eyes)	Sodium hydroxide solid NaOH (s) MW = 40.00 g mol^{-1}  **DANGER** Causes severe skin burns and eye damage
Iron(II) sulfate(VI) solution – 0.2 mol dm^{-3} $FeSO_4$ (aq)  **DANGER** Corrosive (eyes) This solution will need to be made in sulfuric(VI) acid – 1.0 mol dm^{-3}	Iron(II) sulfate(VI)–7–water solid $FeSO_4.7H_2O$ (s) MW = 278.01 g mol^{-1}  **WARNING** Causes skin irritation Causes serious eye irritation
Sulfuric(VI) acid – 1.0 mol dm^{-3} (to make the iron(II) sulfate solution) H_2SO_4 (aq)  **WARNING** Irritant (skin, eyes)	Sulfuric(VI) acid concentrated H_2SO_4 (l) MW = 98.07 g mol^{-1}  **DANGER** Causes severe skin burns and eye damage
Iron(III) nitrate(V) solution – 0.2 mol dm^{-3} $Fe(NO_3)_3$ (aq)  **WARNING** Irritant (skin, eyes) Note: although not usually classified as hazardous at that concentration, the solution should be supplied with a warning due to its very low pH Acid is not required to make that solution	Iron(III) nitrate(V)–9–water solid $Fe(NO_3)_3.9H_2O$ (s) MW = 403.99 g mol^{-1}  **WARNING** Causes skin irritation Causes serious eye irritation May intensify fire; oxidiser
Copper(II) sulfate(VI) solution – 0.2 mol dm^{-3} $CuSO_4$ (aq)  **DANGER** Corrosive (eyes) Irritant (skin)	Copper(II) sulfate(VI)–5–water solid $CuSO_4.5H_2O$ (s) MW = 249.68 g mol^{-1}  **DANGER** Harmful if swallowed Causes skin irritation Causes serious eye damage Very toxic to aquatic life with long lasting effects

Aluminium nitrate solution – 0.2 mol dm^{-3} $Al(NO_3)_3$ (aq) Currently not classified as hazardous	Aluminium nitrate(v)–9–water solid $Al(NO_3)_3.9H_2O$ (s) MW = 375.13 g mol^{-1}  **WARNING** Causes skin irritation Causes serious eye irritation May intensify fire; oxidiser
Calcium chloride – 0.2 mol dm^{-3} $CaCl_2$ (aq) Currently not classified as hazardous	Calcium chloride–6–water solid $CaCl_2.6H_2O$ (s) MW = 219.08 g mol^{-1} Currently not classified as hazardous **Do not use anhydrous calcium chloride to make solutions; the reaction with water is highly exothermic and the water may boil.**
Magnesium chloride solution – 0.2 mol dm^{-3} $MgCl_2$(aq) Currently not classified as hazardous	Magnesium chloride–6–water solid $MgCl_2.6H_2O$ (s) MW = 203.30 g mol^{-1} Currently not classified as hazardous

Take particular care when diluting concentrated acid and using solid sodium hydroxide. Always use splash proof goggles, wear gloves and work in a fume cupboard when diluting acid. Remember to add the acid to the water (check CLEAPSS and SSERC and do not attempt on your own for the first time). When using solid sodium hydroxide, wear goggles and avoid skin contact; avoid rising dust and protect your face when transferring large quantities.

- Iron(III) solutions do not keep well even when made up in acidic solution. Check the iron(III) nitrate solution and replace if necessary. Dispose of by can be diluting further and pouring down a foul-water drain.
- Copper(II) solutions are better made in distilled or deionised water; these solutions are sometimes cloudy. If this is the case, add 1 cm^3 of sulfuric acid 1.0 mol dm^{-3} and stir. Continue this procedure until the solution is clear. Do not make too much copper(II) sulfate solution as a residue can form at the bottom of the container over time. If this happens, filter the solution and dispose of the residue and filter paper in the general waste bin; the concentration might have changed so it is best to test it.

Disposal

The solutions can be kept in the dropper bottles. If replacing the iron(III) solution, dispose of the 'old' solution by diluting further and pouring down a foul-water drain.

The laminating sheet or plastic pocket can be wiped using paper towel which can be disposed of in the normal bin.

Part 3: Testing for negative ions

Equipment (per group)

- 6 x test tubes
- 1 x test tube rack
- 1 x dropping pipette to test for carbon dioxide
- 10 x pipettes if solutions are dispensed in beakers and not in dropping bottles

Safety equipment: safety spectacles.

Preparation

- 0.4 mol dm^{-3} nitric(v) acid solution (no more than 5 ml needed)
- 0.1 mol dm^{-3} silver nitrate(v) solution (no more than 5 ml needed)
- 0.4 mol dm^{-3} barium chloride solution (no more than 5 ml needed)
- 0.5 mol dm^{-3} hydrochloric acid solution (no more than 5 ml needed)
- limewater (maximum 10 ml needed)

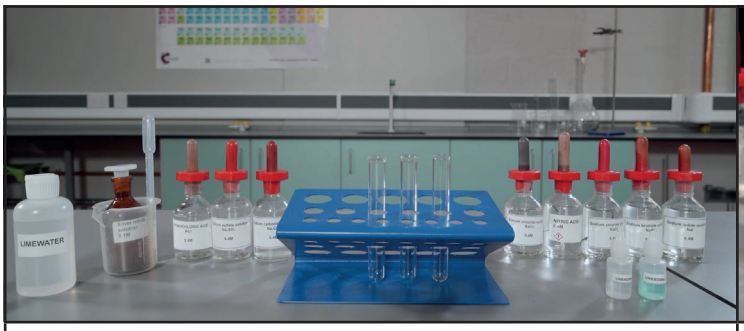
Salt solutions to test (concentrations between 0.1 and 0.5 mol dm^{-3} are suitable):

- For chloride ions– 0.5 mol dm^{-3} sodium or potassium chloride solution (no more than 5 ml needed)
- For bromide ions– 0.5 mol dm^{-3} sodium or bromide solution (no more than 5 ml needed)
- For iodide ions– 0.5 mol dm^{-3} sodium or potassium iodide solution (no more than 5ml needed)
- For sulfate ions– 0.5 mol dm^{-3} sodium sulfate (VI) solution (no more than 5 ml needed)
- For carbonate ions– 0.5 mol dm^{-3} sodium carbonate solution (no more than 5 ml needed)

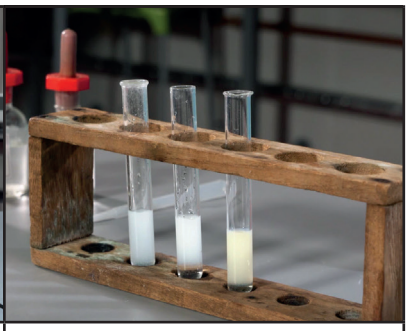
Unknown solutions:

- The number of unknown solutions will depend upon the time available. It's a good idea to use at least 4 solutions. Please label A, B,C and D and make sure that you keep a record of what they are.

Equipment set-up and tips



Use dropper bottles or bottles with individual droppers to avoid contamination.



Solutions can be diluted down and poured down a foul-water drain.

Safety

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Refer to SSERC/CLEAPSS Hazcards and recipe sheets.

Hazard classification may vary depending on supplier.

Chemical supplied for the practical	Preparation
Nitric(v) acid solution – 0.4 mol dm^{-3} HNO_3(aq)  **WARNING** Irritant (skin, eyes)	Nitric(v) acid concentrated solution HNO_3(aq) MW = 63.01 g mol^{-1}  **DANGER** May intensify fire; oxidizer Causes severe skin burns and eye damage Corrosive to the respiratory track
Silver nitrate(v) solution – 0.1 mol dm^{-3} $AgNO_3$ (aq)  **WARNING** Irritant (skin, eyes)	Silver nitrate(v) solid $AgNO_3$ (s) MW = 169.87 g mol^{-1}  **DANGER** May intensify fire; oxidiser Causes severe skin burns and eye damage Very toxic to aquatic life with long lasting effects
Barium chloride solution – 0.4 mol dm^{-3} $BaCl_2$ (aq)  **WARNING** Harmful (ingestion)	Barium chloride–2–water solid $BaCl_2.2H_2O$ (s) MW = 244.26 g mol^{-1}  **DANGER** Toxic if swallowed Harmful if inhaled
Hydrochloric acid solution – 0.5 mol dm^{-3} HCl (aq) Currently not classified as hazardous	Hydrochloric acid concentrated solution HCl (aq) MW = 36.46 g mol^{-1}  **DANGER** Causes severe skin burns and eye damage May cause respiratory irritation
Limewater Currently not classified as hazardous despite having a pH of 12.4. It is advised to treat it as a skin and eye irritant.	Calcium hydroxide solid $CaOH)_2$ MW = 74.09 g mol^{-1}  **DANGER** Causes skin irritation and serious eye damage. May cause respiratory irritation.

Sodium chloride solution – 0.5 mol dm^{-3} NaCl (aq) Currently not classified as hazardous *or* potassium chloride solution – 0.5 mol dm^{-3} KCl (aq) Currently not classified as hazardous	Sodium chloride solid NaCl (s) MW = 58.44 g mol^{-1} Currently not classified as hazardous potassium chloride solid KCl (s) MW = 75.55 g mol^{-1} Currently not classified as hazardous
Sodium bromide solution – 0.5 mol dm^{-3} NaBr (aq) Currently not classified as hazardous *or* potassium bromide solution – 0.5 mol dm^{-3} KBr (aq) Not usually classified as hazardous	Sodium bromide solid NaBr (s) MW = 102.89 g mol^{-1} Currently not classified as hazardous potassium bromide solid KBr (s) MW = 119.00 g mol^{-1} Currently not classified as hazardous
Sodium iodide solution – 0.5 mol dm^{-3} NaI (aq) Currently not classified as hazardous *or* potassium iodide solution – 0.5 mol dm^{-3} KI (aq) Currently not classified as hazardous	Sodium iodide solid NaI (s) MW = 149.89 g mol^{-1} Currently not classified as hazardous potassium iodide solid KI (s) MW = 166.00 g mol^{-1} Currently not classified as hazardous
Example of suitable sulfate solutions: sodium sulfate(VI) solution – 0.5 mol dm^{-3} Na_2SO_4 (aq) Currently not classified as hazardous *or* potassium sulfate(VI) solution – 0.5 mol dm^{-3} K_2SO_4 (aq) Currently not classified as hazardous	Sodium sulfate(VI)–10–water solid $Na_2SO_4.10H_2O$ (s) MW = 322.20 g mol^{-1} Currently not classified as hazardous potassium sulfate(VI) solid K_2SO_4 (s) MW = 174.26 g mol^{-1} Currently not classified as hazardous

Example of suitable sulfate solutions: sodium carbonate solution – 0.5 mol dm^{-3} Na_2CO_3 (aq) Currently not classified as hazardous *or* potassium carbonate solution – 0.5 mol dm^{-3} K_2CO_3 (aq) Currently not classified as hazardous	Sodium carbonate–10–water solid MW = 3286.14 g mol^{-1} $Na_2CO_3.10H_2O$ (s)  **WARNING** Causes serious eye irritation Potassium carbonate solid K_2CO_3 (s) MW = 138.21 g mol^{-1}  **WARNING** Causes serious eye irritation

Take particular care when diluting concentrated acid. Always use splash proof goggles, wear gloves and work in a fume cupboard when diluting acid. Remember to add the acid to the water (check CLEAPSS and SSERC and do not attempt on your own for the first time).

- Silver nitrate solution can stain skin and clothes.
- Try all the prepared solutions, especially the lime water, and adjust the concentrations if necessary.

Disposal

Small amounts of solutions can be diluted and flushed down a foul-water drain. Precipitates can be separated by filtration or decanted (barium sulfate particles easily block filter paper) and they can be placed in the normal refuse.

Solutions can be kept in dropping bottles to be used at a later date. Decant limewater in a larger bottle and filter if necessary before next use.