Testing for negative ions

This activity is in two parts – in the first, students make observations while carrying out the tests for various negative ions. In the second, they use their observations to help them identify the negative ions present in a number of unknown solutions. To make the second part of the exercise more challenging, tests for positive ions could be introduced and students could be asked to identify both the positive and negative ions present in a solution.

Apparatus and chemicals

- Eye protection
- The exact concentrations of the test solutions are not important. Use approximately 0.1–0.5 mol dm^{-3} for salt solutions and 0.5–1.0 mol dm^{-3} for acid solutions, except for nitric acid, which is corrosive at such concentrations (use 0.4 mol dm^{-3} instead).
- Test-tubes
- Dropping pipettes (these can be used just for the carbon dioxide testing or also for dispensing solutions; if the latter, far more pipettes will be required)
- Nitric acid 0.4 mol dm^{-3} (**Irritant**)
- Silver nitrate solution 0.1 mol dm^{-3}
- Barium chloride solution 0.1 mol dm^{-3} (**Harmful**)
- Hydrochloric acid
- Aluminium powder (**Highly flammable**)
- Sodium hydroxide solution less than 0.5 mol dm^{-3} (**Irritant**)
- Limewater
- Red litmus paper
- Ammonia solution 0.4 mol dm^{-3}.

For the initial observations

- Sodium or potassium chloride solution
- Sodium or potassium bromide solution
- Sodium or potassium iodide solution
- Sulfate solution, eg sodium sulfate
- Carbonate solution, eg potassium carbonate
- Nitrate solution, eg potassium nitrate.

For testing unknowns

The number of unknowns required depends on the time available. It is a good idea to use at least four solutions to ensure students are challenged. Label the solutions A, B, C etc and make sure you know which is which.

Technical notes

- **Health and safety:** Wear eye protection.
- Barium chloride solid is **toxic;** the 0.1 mol dm^{-3} solution is **harmful.** Wash your hands after use and warn students to do the same.
- Ammonia solution is an **irritant** when concentrated but not at the concentrations used by students in this activity. However, it can give off ammonia vapour, which can **irritate** the eyes and lungs. Keep the lid on the bottle when not in use.
- Nitric acid is an **irritant.**
- Silver nitrate solution can stain skin and clothes.

Tests for negative ions – expected observations

Negative ion	**Test**	**Observations**
CO_3^{2-} carbonate	Put a small amount of limewater into a test-tube (no more than 1 cm^3). Put your sample in a separate test tube and add a few drops of hydrochloric acid. Using a pipette, collect the gas given off and bubble it through the limewater. (Note: you can also do this test on a solid sample.)	Bubbles of gas form. The gas turns the limewater milky, which shows that it is carbon dioxide.
Cl^- chloride	Add a few drops of dilute nitric acid followed by a few drops of silver nitrate solution. Let the mixture stand for a few minutes and then add some ammonia solution.	A white precipitate forms which discolours on standing. The precipitate is soluble in ammonia solution.
Br^- bromide	Add a few drops of dilute nitric acid followed by a few drops of silver nitrate solution. Let the mixture stand for a few minutes and then add some ammonia solution.	A cream precipitate forms which discolours a little on standing. The precipitate is slightly soluble in ammonia solution.
I^- iodide	Add a few drops of dilute nitric acid followed by a few drops of silver nitrate solution. Let the mixture stand for a few minutes and then add some ammonia solution.	A yellow precipitate forms which does not discolour on standing. The precipitate is insoluble in ammonia solution.
SO_4^{2-} sulfate	Add a few drops of barium chloride solution and then a few drops of hydrochloric acid.	A white precipitate forms.
NO_3^- nitrate	Add a few drops of sodium hydroxide solution and a little aluminium powder. Warm the solution in a Bunsen flame and test any gas given off using red litmus paper.	A gas is given off which turns the litmus blue. This shows that the gas is ammonia.

Equations

$NaCl(aq) + AgNO_3(aq) \rightarrow NaNO_3(aq) + AgCl(s)$

$Cl^-(aq) + Ag^+(aq) \rightarrow AgCl(s)$ (and similarly for Br^- and I^-)

$Na_2SO_4(aq) + BaCl_2(aq) \rightarrow 2NaCl(aq) + BaSO_4(s)$

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

$2HCl(aq) + Na_2CO_3(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$

$CO_3^{2-}(aq) + 2H^+(aq) \rightarrow CO_2(g) + H_2O(l)$

For completeness, the reaction with the nitrate ion is shown below. It is unlikely that students will be able to construct this for themselves and the student sheet does not ask them to do so.

$8Al(s) + 3NO_3^-(aq) + 5OH^-(aq) + 18H_2O(l) \rightarrow 8[Al(OH)_4]^-(aq) + 3NH_3(g)$

Reference

This experiment has been reproduced from *Inspirational Chemistry*, Royal Society of Chemistry, London, p.177-179 and Index 7.3.1

Further problem solving ideas

There are several suggestions in C. Wood, *Creative Problem Solving in Chemistry*, London: Royal Society of Chemistry, 1993.

Credits

Health & safety checked January 2018

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