Testing for negative ions

Introduction

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.

Equipment

Apparatus

- Eye protection
- Test tubes
- Pipettes
- Red litmus paper

Chemicals

- Nitric acid 0.4 mol dm^{-3}
- Silver nitrate solution 0.1 mol dm^{-3}
- Barium chloride solution 0.1 mol dm^{-3}
- Hydrochloric acid
- Aluminium powder
- Sodium hydroxide solution less than 0.5 mol dm^{-3}
- Limewater
- 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

Health, safety and technical notes

- Read our standard health and safety guidance here https://rsc.li/3O5xB9s
- Always 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. (See CLEAPSS Hazcard HC010a)
- 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. (See CLEAPSS Hazcard HC006)
- Nitric acid is an irritant. (See CLEAPSS Hazcard HC067)
- Silver nitrate solution can stain skin and clothes. (See CLEAPSS Hazcard HC087)

Procedure

CO3–2 carbonate

1. Put a small amount of limewater into a test (no more than 1 cm^3).
2. Put your sample in a separate test tube and add a few drops of hydrochloric acid.
3. 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).
4. Bubbles of gas form. The gas turns the limewater milky, which shows that it is carbon dioxide.

Cl− chloride

1. Add a few drops of dilute nitric acid followed by a few drops of silver nitrate solution.
2. Let the mixture stand for a few minutes and then add some ammonia solution
3. A white precipitate forms which discolours on standing.
4. The precipitate is soluble in ammonia solution

Br− bromide

1. Add a few drops of dilute nitric acid followed by a few drops of silver nitrate solution.
2. Let the mixture stand for a few minutes and then add some ammonia solution.
3. A cream precipitate forms, which discolours a little on standing.
4. The precipitate is slightly soluble in ammonia solution.

I− iodide

1. Add a few drops of dilute nitric acid followed by a few drops of silver nitrate solution.
2. Let the mixture stand for a few minutes and then add some ammonia solution.
3. A yellow precipitate forms which does not discolour on standing.
4. The precipitate is insoluble in ammonia solution.

SO4–2 sulfate

1. Add a few drops of barium chloride solution and then a few drops of hydrochloric acid.
2. A white precipitate forms.

NO3– nitrate

1. Add a few drops of sodium hydroxide solution and a little aluminium powder.
2. Warm the solution in a Bunsen flame and test any gas given off using red litmus paper.
3. A gas is given off which turns the litmus blue.
4. This shows that the gas is ammonia.

Notes

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.

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^-)

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

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

$2HCl(aq) + Na2CO3(aq) \rightarrow 2NaCl(aq) + H2O(l) + CO2(g)$

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

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.

$8Al(s) + 3NO^{3-}(aq) + 5OH^-(aq) + 18H_2O(l) \rightarrow 8[Al(OH)_4]^-(aq) + 3NH_3(g)$