80. Testing salts for anions and cations

Topic

Qualitative analysis.

Timing

1–2 hours.

Description

Students attempt to identify the anions and cations present in a salt by a combination of tests.

Apparatus and equipment (per group)

- Test-tubes.

Chemicals (per group)

Access to:

- Full range indicator paper
- Ammonia solution 2 mol dm$^{-3}$ (Irritant)
- Sodium hydroxide solution 0.4 mol dm$^{-3}$
- Hydrochloric acid solution 0.4 mol dm$^{-3}$ (Irritant)
- Barium chloride solution 0.1 mol dm$^{-3}$ (Harmful)
- Limewater solution 0.02 mol dm$^{-3}$
- Nitric acid 0.4 mol dm$^{-3}$ (Irritant)
- Silver nitrate solution 0.1 mol dm$^{-3}$

- 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), potassium carbonate, potassium iodide, copper(II) sulfate (Harmful), iron(III) chloride (Irritant), iron(II) sulfate, lead nitrate (Toxic).

Extension – for flame tests

Nichrome wire loops attached to wooden handles (cleaned before lesson in concentrated hydrochloric acid).

Safety

Wear eye protection. Ammonia solution causes burns and gives off ammonia vapour which irritates the eyes, lungs and respiratory system.

Sodium hydroxide can cause burns and is dangerous to the eyes.

Hydrochloric acid can cause burns.

Barium chloride is harmful by inhalation and if swallowed.

Nitric acid causes burns.
Silver nitrate solution causes burns.

**Teaching tips**

Test-tubes should be washed initially. Thorough washing to prevent contamination is important.

**Flame tests**

It is probably inadvisable to use concentrated hydrochloric acid to produce volatile chlorides at this level. This procedure should be effective as long as sodium, which produces a persistent yellow colour, is not given as an unknown.


This experiment is probably suitable for able 15/16 year old students in this format. Teachers may wish to adapt this for less able students and or spread the work over 2 or 3 lessons.

**Background theory**

A knowledge of precipitation reactions is helpful as is pre-knowledge of the chemistry of the tests. Otherwise, the students should test known substances to ensure they know what is a positive result.
Testing salts for anions and cations

Introduction

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

What to record

<table>
<thead>
<tr>
<th>Sample</th>
<th>Test performed</th>
<th>Result of test</th>
</tr>
</thead>
</table>

What to do

1. Dissolve the unknown substance in deionised water. 5–10 cm³ of solution may be needed.
2. Using the analysis table, test small aliquots (portions).
3. Repeat for the other unknown substances.

Safety

Wear eye protection. Some of the unknowns may be toxic or corrosive.

Questions

1. Write word and ionic equations for those reactions that give a positive result.
Testing salts for anions and cations.

For anions: carry out the three tests A, B and C below:

<table>
<thead>
<tr>
<th>Test</th>
<th>Anion</th>
<th>Test and observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Chloride (Cl(^-))</td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td>Bromide (Br(^-))</td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td>Iodide (I(^-))</td>
<td>Add a few drops of dilute nitric acid followed by a few drops of silver nitrate solution. A yellow precipitate of silver iodide is formed. It is insoluble in ammonia solution.</td>
</tr>
<tr>
<td>B</td>
<td>Sulfate (SO(_4)^{2-}))</td>
<td>Add a few drops of barium chloride solution (Toxic) followed by a few drops of dilute hydrochloric acid. A white precipitate of barium sulfate is formed.</td>
</tr>
<tr>
<td>C</td>
<td>Carbonate (CO(_3)^{2-}))</td>
<td>Add dilute hydrochloric acid to the solution (or add it to the solid). Bubbles of carbon dioxide are given off.</td>
</tr>
</tbody>
</table>

For cations: carry out the two tests D and E below:

<table>
<thead>
<tr>
<th>Cation</th>
<th>D Add sodium hydroxide solution (Irritant)</th>
<th>E Add ammonia solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonium (NH(_4)^+(aq))</td>
<td>Warm carefully. Do not allow to spit. Ammonia (alkali gas) is given off</td>
<td>————</td>
</tr>
</tbody>
</table>
Flame tests.

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 below.

<table>
<thead>
<tr>
<th>Metal</th>
<th>Colour of flame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barium</td>
<td>Apple-green</td>
</tr>
<tr>
<td>Calcium</td>
<td>Brick-red</td>
</tr>
<tr>
<td>Copper</td>
<td>Green with blue streaks</td>
</tr>
<tr>
<td>Lithium</td>
<td>Crimson</td>
</tr>
<tr>
<td>Potassium</td>
<td>Lilac</td>
</tr>
<tr>
<td>Sodium</td>
<td>Yellow</td>
</tr>
</tbody>
</table>