12. Iron chemistry
- variable oxidation state

**Topic**
Iron chemistry, transition elements, oxidation states, precipitation and redox reactions, complexes.

**Timing**
20 min.

**Apparatus (per group)**
- One student worksheet
- One clear plastic sheet (e.g. OHP sheet)
- Magnifying glass.

**Chemicals (per group)**
Solutions contained in plastic pipettes, see p. 2

- Sodium hydroxide \(1\ \text{mol dm}^{-3}\)
- Potassium manganate(VII) \(0.01\ \text{mol dm}^{-3}\)
- Potassium iodide \(0.2\ \text{mol dm}^{-3}\)
- Iron(II) sulphate \(0.2\ \text{mol dm}^{-3}\)
- Iron(III) nitrate \(0.2\ \text{mol dm}^{-3}\)
- Silver nitrate \(0.2\ \text{mol dm}^{-3}\)
- Potassium thiocyanate \(0.1\ \text{mol dm}^{-3}\)
- Starch solution (freshly made).

**Observations**
1. The addition of sodium hydroxide produces a gelatinous green precipitate with iron(II) solution and a brown precipitate with iron(III) solution. On standing, oxidation causes the iron(II) hydroxide to turn a brown-yellow colour due to gradual formation of iron(III) hydroxide.
   \[
   \text{Fe}^{2+}(aq) + 2\text{OH}^-(aq) \rightarrow \text{Fe(OH)}_2(s)
   \]

2. The thiocyanate ion gives a deep red colour with iron(III) but should give virtually no colour with iron(II). However, unless it is very pure and freshly prepared, iron(II) will probably give a faint red colour due to the presence of some iron(III).

3. Iron(III) oxidises iodide ions to iodine which gives the characteristic blue-black
colour with starch. Iron(II) should give no reaction unless it contains some iron(III).

\[ 2\text{Fe}^{3+}(aq) + 2\text{I}^-(aq) \rightarrow \text{I}_2(aq) + 2\text{Fe}^{2+}(aq) \]

4. The deep purple colour of manganate(VII) ions gradually diminishes as it is reduced by iron(II) whereas iron(III) has no effect.

\[ \text{MnO}_4^-(aq) + 5\text{Fe}^{2+}(aq) + 8\text{H}^+(aq) \rightarrow \text{Mn}^{2+}(aq) + 5\text{Fe}^{3+}(aq) + 4\text{H}_2\text{O}(l) \]

5. The reaction of silver nitrate and iron(II) ions produces a glittering of metallic silver which is seen using a magnifying glass. There is no corresponding reaction with iron(III) ions.

**Tips**

These experiments can be done quickly so students might be encouraged to develop their explanations for the reactions. A book of data would be useful so that students can look up redox potentials. A biochemical development would be to consider the role of iron in haemoglobin and the types of iron compounds found in iron tablets (Iron(II) is required for haemoglobin, the +2 oxidation state being stabilised by complexation.)

The fact that many iron(II) compounds contain some iron(III) could form the basis of a discussion on the purities of chemical compounds.

**Safety**

Students must wear eye protection.

It is the responsibility of the teacher to carry out a risk assessment.
12. Iron chemistry - variable oxidation state

The purpose of this experiment is to compare the chemistry of the two main oxidation states of iron (a first row transition element) and to consider explanations for any differences observed. Carefully follow the instructions below noting down all your observations and trying to give explanations.

Instructions

1. Cover the worksheet with a clear plastic sheet.
2. Put one drop of iron(II) solution in each box in the second row.
3. Put one drop of iron(III) solution in each box in the third row.
4. Add two drops of sodium hydroxide solution to each drop in the boxes in the second column. Observe and note whether there are any changes over the next 10 min.
5. Add one drop of potassium thiocyanate solution to each drop in the third column.
6. Add one drop of potassium iodide solution to each drop in the fourth column. After one minute, add one drop of starch solution to each.
7. Add one drop of potassium manganate(VII) solution to each drop in the fifth column. Observe changes over the next 10 min.
8. Add one drop of silver nitrate solution to each drop in the sixth column. Observe closely using a magnifying glass.

<table>
<thead>
<tr>
<th>Solutions of</th>
<th>Hydroxide ions</th>
<th>Thiocyanate ions</th>
<th>Iodide ions</th>
<th>Manganate (VII) ions</th>
<th>Silver(I) ions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron(II) ions</td>
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<tr>
<td>Iron(III) ions</td>
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Questions

1. What explanations can you give for your observations?
2. Can you write equations for the reactions you observe?