Investigation of
(a) Redox reactions of the halogens
(b) Displacement reactions of metals

Theory

The halogens, fluorine, chlorine, bromine, iodine and astatine are very reactive elements and are too unstable to exist in nature in an uncombined form. They often react by taking an electron from another element. This means they react as **oxidising agents**. The smaller the halogen atom, the stronger the oxidising agent it is. So in terms of oxidising power

F > Cl > Br > I > At

Fluorine is extremely poisonous, and astatine is unstable and radioactive, so the investigation here is confined to the other three halogens.

(i) Reactions with halides

Chlorine, being the strongest oxidising agent of the three, is capable of releasing the other two elements from solutions of their salts:

$Cl_2 + 2Br^-_{(aq)} \rightarrow 2Cl^-_{(aq)} + Br_2$

$Cl_2 + 2I^-_{(aq)} \rightarrow 2Cl^-_{(aq)} + I_2$

Bromine can release iodine from a solution of its salts

$Br_2 + 2I^-_{(aq)} \rightarrow 2Br^-_{(aq)} + I_2$

Your task is to find the evidence to support this theory.

Chemicals and Apparatus

- ✓ Chlorine solution 
- ✓ Bromine solution 
- ✓ Iodine solution
- ✓ Sodium chloride solution
- ✓ Sodium bromide solution
- ✓ Potassium iodide solution

- ✓ Safety glasses
- ✓ PVC gloves
- ✓ Fume cupboard or well-ventilated room
- ✓ Pasteur pipettes
- ✓ Test tubes
- ✓ Test tube rack
- ✓ Test tube brush

Quantities needed per working group

Name of solution	**Quantity**
Aqueous solutions of chlorine, bromine and iodine.	2 cm^3 aliquots (portions) per test
Aqueous solutions of chloride, bromide, and iodide salts.	2 cm^3 aliquots per test

Procedure

NB: Wear your safety glasses.

Copy the following table into your practical report book and fill in your observations. By reference to this table you will be able to draw conclusions from your later observations.

Name of solution	**Colour of solution**
Chlorine in water	
Bromine in water	
Iodine in water	
Chloride ions in water	
Bromide ions in water	
Iodide ions in water	

Table 1

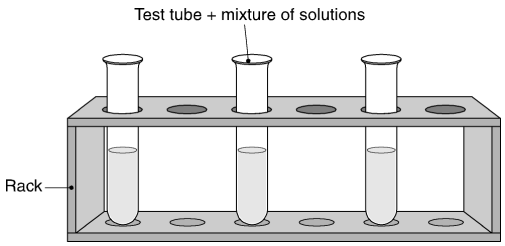
Draw a second table into your practical report book with the following headings:

Solutions added to the test-tube	**Observation**	**Conclusion**
(a) Chlorine and bromide ions		
(b) Chlorine and iodide ions		
(c) Bromine and iodide ions		

Table 2

As there are as many as 16 reagent bottles in use in these experiments it is vital to the success of the experiment not to mix the reagents by putting the wrong stopper on the wrong bottle. Your teacher will demonstrate to you the correct way to hold the stopper while using a reagent bottle. **Always replace stoppers immediately after use.**

For each of the cases (a), (b) and (c) described in Table 2, add 2 cm^3 of the solutions mentioned to separate test tubes and mix.



Record your observations and conclusions. Retain the contents of the test tubes for comparison purposes, ensuring that the test tubes are correctly labelled.

(ii) Reactions with iron(II) salts and with sulfites

All three halogen solutions are able to oxidise iron(II) ions to iron(III) ions, and to oxidise sulfite ions to sulfate ions in aqueous solution. For example, chlorine reacts as follows:

$Cl_2 + 2Fe^{2+}_{(aq)} \rightarrow 2Cl^-_{(aq)} + 2Fe^{3+}_{(aq)}$

$Cl_2 + SO_3^{2-}_{(aq)} \rightarrow 2Cl^-_{(aq)} + SO_4^{2-}_{(aq)}$

Your task is to find the evidence to support this theory.

Chemicals and Apparatus

- ✓ Chlorine solution 
- ✓ Iron(II) sulfate solution 
- ✓ Iron(III) chloride solution 
- ✓ Sodium sulfite solution
- ✓ Sodium hydroxide solution 
- ✓ Silver nitrate solution
- ✓ Barium chloride solution 
- ✓ Dilute hydrochloric acid 
- ✓ Dilute ammonia solution 
- ✓ Safety glasses
- ✓ PVC gloves
- ✓ Fume cupboard or well-ventilated room
- ✓ Pasteur pipettes
- ✓ Test tubes
- ✓ Test tube rack
- ✓ Test tube brush

Quantities needed per working group

Name of solution	**Quantity**
Aqueous solutions of chlorine, bromine and iodine.	2 cm^3 aliquots (portions) per test
Aqueous solutions of iron(II) sulfate, iron(III) chloride and sodium sulfite.	2 cm^3 aliquots per test
Sodium hydroxide solution.	2 cm^3
Aqueous solutions of silver nitrate, barium chloride, dilute hydrochloric acid and dilute ammonia.	2 cm^3 aliquots per test

Procedure

NB: Wear your safety glasses.

Copy the following table into your practical report book and fill in your observations. By reference to this table you will be able to draw conclusions from your later observations.

Name of solution	**Colour of solution**
Chlorine in water	
Iron(II) sulfate in water	
Iron(III) chloride in water	
Iron(II) ions in sodium hydroxide solution	
Iron(III) ions in sodium hydroxide solution	

Table 3

Draw another table into your practical report book with the following headings:

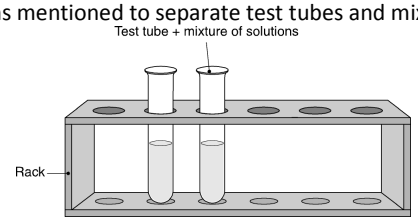
Solutions added to the test-tube	**Observation**	**Conclusion**
(d) Chlorine and iron(II) sulfate followed by 10 drops of sodium hydroxide		
(e) Chlorine and sodium sulfite followed by the test for the presence of chloride ions **or** sulfate ions		

Table 4

Check that the sulfite solution does **not** contain any sulfate ions, as follows: Add 2 cm^3 of sodium sulfite solution to a clean test tube. Using a dropping pipette add a few drops of barium chloride solution. A white precipitate forms. Now add 2 cm^3 of dilute hydrochloric acid. The white precipitate should dissolve. If any of the white precipitate does not dissolve, then sulfate ions are present, and so this solution cannot be used.

Check that the iron(II) sulfate solution does **not** contain any iron(III) ions by adding 10 drops of sodium hydroxide solution and studying the colour of the precipitate formed and comparing it with the table set up in part 1.

For each of the cases (d) and (e) described in Table 4, add 2 cm^3 of the solutions mentioned to separate test tubes and mix.



Record your observations and conclusions. Retain the contents of the test tubes for comparison purposes, ensuring that the test tubes are correctly labelled.

Iron(II) ions and iron(III) ions form different coloured floating (flocculent) precipitates with sodium hydroxide. This allows you to determine whether a reaction has or has not taken place in (d) above.

In (e) above, the test for sulfate ions is carried out as described in 3 above. The test for chloride ions is carried out as follows: Add the solution to be tested to a clean test tube. Using a dropping pipette add a few drops of silver nitrate solution. If chloride is present, a white precipitate forms. Now add 2 cm^3 of dilute ammonia solution. The white precipitate should dissolve.