

Appendix 2

21. Some redox reactions of halogens and halides – Student Sheet

In these two experiments you will investigate how the halogen elements react with the different halide ions, chloride, bromide and iodide. You will also observe and explain how concentrated sulphuric acid reacts with halide ions.

Intended lesson outcomes

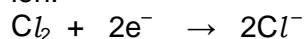
By the end of this practical you should be able to:

- describe the relative reactivity of the halogen elements as oxidising agents;
- describe and explain the reactions of halide ions with concentrated sulphuric acid;
- describe and explain redox processes in terms of electron transfer and/or changes of oxidation number.

Experiment 1. Reactions of halogens with halide solutions

Background information






The Group VII elements are called halogens. They all accept one electron to form a halide ion.



Questions

- Write similar half-equations to the one above for bromine and iodine.
 - Using ideas of electron gain and loss, explain whether these half-equations are oxidation or reduction reactions.
 - Using oxidation numbers, explain whether these are oxidation or reduction half-reactions.

Safety

	You must wear eye protection throughout this experiment.
 	Chlorine solution is irritant and liberates a toxic gas . Asthmatics need to be particularly careful. Use of a fume cupboard is advised.
 	Bromine solution is harmful and irritant (use of a fume cupboard is advised), and is dangerous to the environment

Procedure

You have three halogen solutions, chlorine water, bromine water and iodine water. You also have test tubes containing potassium chloride, potassium bromide and potassium iodide.

- Place a piece of universal indicator paper on a white tile.

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- Use a glass stirring rod to transfer a few drops of the first halogen solution in the table below onto the indicator paper and repeat with fresh paper for the other two solutions. Record your results in the table.
- Add some chlorine solution separately to test tubes containing solutions of potassium bromide and potassium iodide. Record your observations in the table below.
- Now mix solutions of bromine with potassium chloride and potassium iodide solutions and fill in the next row of the table.
- Repeat using mixtures of iodine solution and potassium chloride and iodine solution and potassium bromide. Record your results in the table.

	<i>effect on indicator paper</i>	<i>reaction with potassium chloride solution</i>	<i>reaction with potassium bromide solution</i>	<i>reaction with potassium iodide solution</i>
<i>chlorine water</i>				
<i>bromine water</i>				
<i>iodine water</i>				

Questions

- Which halogen solution has the greatest effect on the indicator paper?
- Write balanced ionic equations for the reactions that occurred between halogen solutions and halide solutions.
- Which halogen is the strongest oxidising agent and which halogen is the least oxidising?

Experiment 2. Reactions of solid halides with concentrated sulphuric acid

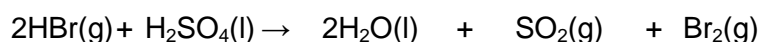
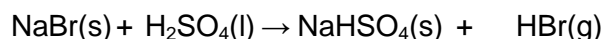
Background information

Concentrated sulphuric acid reacts with solid halides to form the corresponding hydrogen halide.

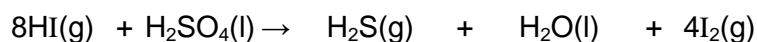


The reaction is complicated by the fact that concentrated sulphuric acid is an oxidising agent. Hydrogen chloride and chloride ions are the most difficult to oxidise and concentrated sulphuric acid is not a strong enough oxidising agent to oxidise them.

Hydrogen bromide and bromide ions are more easily oxidised.










Hydrogen iodide and iodide ions are even more easily oxidised by concentrated sulphuric acid, and sulphur dioxide, iodine and hydrogen sulphide are all produced.



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Safety

	You must wear eye protection throughout this experiment.
	Concentrated sulphuric acid is corrosive .
	Ammonia solution is harmful
	and dangerous to the environment
	These reactions liberate harmful and toxic gases . Asthmatics need to be particularly careful. Everyone should use only the very small quantities suggested and avoid inhaling the vapours directly from the tubes.
	
	Potassium dichromate(VI) is toxic . Do not allow it to come in contact with your skin. Wear gloves when handling filter paper soaked with this solution.

Procedure

- Put about five sodium chloride crystals in the bottom of a boiling tube and add five drops of concentrated sulphuric acid.
- Test the emerging gas with damp indicator paper and blow across the mouth of the tube. Record your observations.
- Using a glass rod, hold a drop of ammonia solution near the mouth of the tube. Again, record what happens.
- Repeat Step 1 using a few crystals of potassium bromide or potassium iodide. Test the gases coming off firstly with filter paper soaked with potassium dichromate(VI)(aq), which will turn from orange to green in the presence of sulphur dioxide. Write down all the observations you make about these reactions. Look carefully at the 'Background information' to help you identify some of the products.

Questions

- Write the equation for the production of hydrogen iodide from sodium iodide before it is oxidised.
- What are the oxidation numbers of sulphur and chlorine in the first equation in the 'Background information' for this experiment?
- What changes of oxidation number occur for sulphur and bromine in the third equation in the 'Background information'?
- What changes of oxidation number occur in the last equation in the 'Background information'?
- A yellow solid may also be seen in the reaction with sodium iodide. What substance is this? What does this tell you about the reducing power of iodine?

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21. Some redox reactions of halogens and halides – Teachers' Notes

These two experiments set the scene for understanding the relative oxidising and reducing powers of the halogens and their halide ions.

Learning outcomes

These are printed on the Student Sheet.

A suggested approach

This is a good opportunity to remind students about redox reactions, in terms of change of oxidation numbers. After the 'Background information' to Experiment 1, questions are provided to test their understanding. Following the necessary safety warnings, the students could then carry out the reactions. The first task is to consider the bleaching action of the halogens. This gives a clear indication that chlorine is the most reactive, easily bleaching the indicator paper. You could, as a summary, explain that the other reactions are called displacement reactions. As well as discussing the decrease in oxidising power as you descend Group VII, also mention that the reducing power of the halide ion increases as you go down the group.

Experiment 2 extends the ideas of redox reactions to the various reactions of halide ions with concentrated sulphuric acid, which is an oxidising agent. The 'Background information' to this experiment provides some of the theory behind the observations students will make. You will note that we suggest using very small quantities of the reagents and this should be reinforced prior to the practical work.

Technical information

Requirements per student/group:

Experiment 1

Potassium chloride solution (0.1 mol dm^{-3})*
 Potassium bromide solution (0.1 mol dm^{-3})*
 Potassium iodide solution (0.1 mol dm^{-3})*
 Chlorine solution (0.05 mol dm^{-3})* (**liberates toxic gas**)
 Bromine solution (0.05 mol dm^{-3})*
 Iodine solution (0.01 mol dm^{-3})*
 Ammonia solution – e.g. 2 mol dm^{-3}
 White tile
 Universal indicator paper
 Test tubes
 Test-tube rack

*It is not necessary for the concentrations of the above solutions to be highly accurate.

Experiment 2

Concentrated sulphuric acid
 A few crystals of sodium chloride, potassium bromide and potassium iodide
 Filter paper soaked with potassium dichromate(VI) solution
 Ammonia solution – e.g. 2 mol dm^{-3}
 Universal indicator paper
 Boiling tubes
 Test-tube rack, able to accommodate boiling tubes

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Safety

The main points are included on the Student Sheet but it is the teacher's responsibility to ensure that a full risk assessment is carried out prior to the practical session. Sulphur dioxide and chlorine gas may be present in some of these reactions and asthmatics should be particularly careful not to inhale the vapours. A well-ventilated laboratory is essential. With iodine and concentrated sulphuric acid, some hydrogen sulphide is produced, which is toxic. Use of a fume cupboard is advisable.

Answers to questions on the Student Sheet



(b) These are reduction half-reactions as electrons are gained.

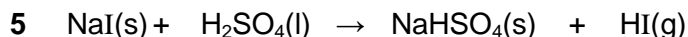
(c) In both cases, the elements have an oxidation number of zero and this changes to -1 . As there is a decrease in oxidation number, these are reduction half-reactions.

2 Chlorine.



4 Chlorine is the strongest oxidising agent as it oxidises bromide and iodide to their respective halogens.

Iodine is the least oxidising agent because it will not oxidise bromide or chloride.



6 They do not change.

7 Bromine changes from -1 to 0 .

Sulphur changes from $+6$ to $+4$.

8 Iodine changes from -1 to 0 .

Sulphur changes from $+6$ in sulphuric acid to -2 in hydrogen sulphide.

9 The yellow solid is sulphur.

Iodine is the most powerful reducing agent out of the three halogens used.