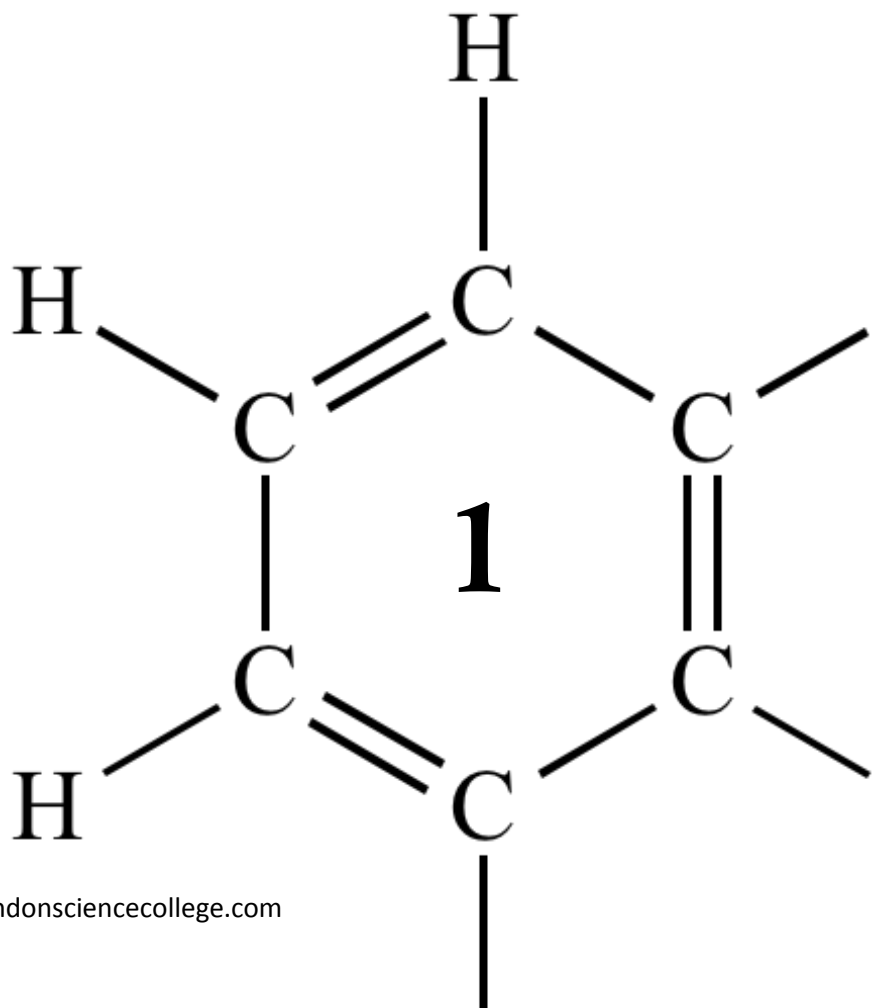


AQA AS CHEMISTRY

# HALOGENS



1

A student oxidised a solution of hydrochloric acid with a few drops of sodium chlorate(I) solution. The reaction mixture effervesced and turned pale green. The gas formed bleached universal indicator paper.

(a) Write a half-equation for the oxidation of chloride ions.

..... (1)

(b) Write a half-equation for the reduction of chlorate(I) ions to chlorine in acidic conditions.

..... (1)

(c) Write an overall equation for the redox reaction of chlorate(I) ions with hydrochloric acid.

..... (1)

(d) A solution of sodium chlorate(I) was added to a colourless solution of potassium iodide. Suggest what is observed.

Explain the reaction that leads to this observation.

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(3)  
(Total 6 marks)

**2**

The halogens are the elements in Group 7.

(a) The electronegativities of the halogens are shown in the table.

| Halogen           | Fluorine | Chlorine | Bromine | Iodine |
|-------------------|----------|----------|---------|--------|
| Electronegativity | 4.0      | 3.0      | 2.8     | 2.5    |

Explain the trend in electronegativities shown by the halogens.

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**(2)**

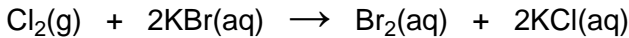
(b) The halogens can all behave as oxidising agents in reactions.

(i) Explain, in terms of electron transfer, the meaning of the term oxidising agent.

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**(1)**

(ii) An equation for the reaction that takes place when chlorine gas is bubbled through aqueous potassium bromide is shown.



Explain, with reference to the oxidation states, why this is a redox reaction.

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**(1)**

(c) Solid sodium halides react with concentrated sulfuric acid.

- (i) A sample of solid sodium iodide is reacted with concentrated sulfuric acid. A black solid forms and hydrogen sulfide gas is produced.

Write a half-equation for the reaction of sulfuric acid to form hydrogen sulfide.

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(1)

- (ii) Write a half-equation for the formation of the black solid.

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(1)

- (iii) Use your answers to parts (c) (i) and (c) (ii) to write an overall equation for the reaction of sodium iodide with concentrated sulfuric acid.

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(1)

- (iv) Give the role of sulfuric acid in its reaction with sodium iodide.

Tick (✓) **one** box.

Acid

Oxidising agent

Reducing agent

Electrophile

(1)

- (v) Write an equation for the reaction of concentrated sulfuric acid with solid sodium fluoride.

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(1)

- (vi) Suggest **one** reason why the reaction of sodium fluoride with concentrated sulfuric acid is different from the reaction with sodium iodide.

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(1)

(d) Chlorine reacts with water to form an equilibrium mixture containing hydrochloric acid and chloric(I) acid.

(i) Write an equation for the formation of this equilibrium mixture.

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(1)

(ii) Household bleach contains sodium chlorate(I) and sodium chloride. State and explain, with reference to your equation in part (d)(i), why it is dangerous to acidify an aqueous mixture of sodium chlorate(I) and sodium chloride.

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(2)

(Total 13 marks)

3

This question is about the chemical properties of chlorine, sodium chloride and sodium bromide.

(a) Sodium bromide reacts with concentrated sulfuric acid in a different way from sodium chloride.

Write an equation for this reaction of sodium bromide and explain why bromide ions react differently from chloride ions.

Equation .....

Explanation .....

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(3)

(b) A colourless solution contains a mixture of sodium chloride and sodium bromide.

Using aqueous silver nitrate and any other reagents of your choice, develop a procedure to prepare a pure sample of silver bromide from this mixture.

Explain each step in the procedure and illustrate your explanations with equations, where appropriate.

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(6)

(c) Write an ionic equation for the reaction between chlorine and cold dilute sodium hydroxide solution.

Give the oxidation state of chlorine in each of the chlorine-containing ions formed.

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(2)

(Total 11 marks)

4

Which of these species is the best reducing agent?

A  $\text{Cl}_2$

B  $\text{Cl}^-$

C  $\text{I}_2$

D  $\text{I}^-$

(Total 1 mark)

**5** Which of these substances reacts most rapidly to produce a silver halide precipitate with acidified silver nitrate?

- A  $\text{CH}_3\text{Br}$
- B  $\text{CH}_3\text{Cl}$
- C  $\text{CH}_3\text{F}$
- D  $\text{CH}_3\text{I}$

(Total 1 mark)

**6** The table below shows observations of changes from some test-tube reactions of aqueous solutions of compounds **Q**, **R** and **S** with five different aqueous reagents. The initial colours of the solutions are not given.

|          | $\text{BaCl}_2 + \text{HCl}$ | $\text{AgNO}_3 + \text{HNO}_3$ | $\text{NaOH}$   | $\text{Na}_2\text{CO}_3$            | $\text{HCl (conc)}$ |
|----------|------------------------------|--------------------------------|---|-------------------------------------|---------------------|
| <b>Q</b> | no change observed           | pale cream precipitate         | white precipitate                                       | white precipitate                   | no change observed  |
| <b>R</b> | no change observed           | white precipitate              | white precipitate, dissolves in excess of $\text{NaOH}$ | white precipitate, bubbles of a gas | no change observed  |
| <b>S</b> | white precipitate            | no change observed             | brown precipitate                                       | brown precipitate, bubbles of a gas | yellow solution     |

(a) Identify each of compounds **Q**, **R** and **S**.  
You are **not** required to explain your answers.

Identity of **Q** .....

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Identity of **R** .....

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Identity of **S** .....

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(6)

(b) Write ionic equations for each of the positive observations with **S**.

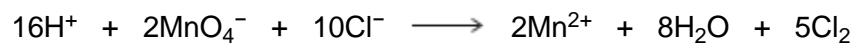
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(4)  
(Total 10 marks)

**7**

Chlorine is an important industrial chemical.

(a) Chlorine is formed when  $\text{KMnO}_4$  reacts with hydrochloric acid.  
The ionic equation for this redox reaction is



(i) Deduce the half-equation for the oxidation of chloride ions to chlorine.

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(1)

(ii) Give the oxidation state of manganese in the  $\text{MnO}_4^-$  ion.

.....

(1)

(iii) Deduce the half-equation for the reduction of the  $\text{MnO}_4^-$  ions in acidified solution to manganese(II) ions and water.

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(1)



(b) Chlorine behaves as an oxidising agent in the extraction of bromine from seawater. In this process, chlorine gas is bubbled through a solution containing bromide ions.

(i) Write the **simplest ionic** equation for the reaction of chlorine with bromide ions.

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(1)

(ii) Give **one** observation that would be made during this reaction.

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(1)

(iii) In terms of electrons, state the meaning of the term **oxidising agent**.

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(1)

(c) In sunlight, chlorine can also oxidise water slowly to form oxygen.

Write an equation for this reaction.

Give the oxidation state of chlorine in the chlorine-containing species that is formed.

Equation

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Oxidation state of chlorine in the species formed .....

(2)

(d) Explain why chlorine has a lower boiling point than bromine.

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(2)

(Total 10 marks)

**8**

The following pairs of compounds can be distinguished by simple test-tube reactions.

For each pair of compounds, give a reagent (or combination of reagents) that, when added separately to each compound, could be used to distinguish between them. State what is observed in each case.

(a) Butan-2-ol and 2-methylpropan-2-ol

Reagent .....

Observation with butan-2-ol

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Observation with 2-methylpropan-2-ol

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**(3)**

(b) Propane and propene

Reagent .....

Observation with propane

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Observation with propene

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**(3)**

(c) Aqueous silver nitrate and aqueous sodium nitrate

Reagent .....

Observation with aqueous silver nitrate

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Observation with aqueous sodium nitrate

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**(3)**

(d) Aqueous magnesium chloride and aqueous barium chloride

Reagent .....

Observation with aqueous magnesium chloride

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Observation with aqueous barium chloride

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(3)  
(Total 12 marks)

9

For many years, swimming pool water has been treated with chlorine gas. The chlorine is added to kill any harmful bacteria unintentionally introduced by swimmers. Pool managers are required to check that the chlorine concentration is high enough to kill the bacteria without being a health hazard to the swimmers.

When chlorine reacts with water in the absence of sunlight, the chlorine is both oxidised and reduced and an equilibrium is established.

(a) Write an equation for this equilibrium.

For each chlorine-containing species in the equation, write the oxidation state of chlorine below the species.

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(2)

(b) The pool manager maintains the water at a pH slightly greater than 7.0

Explain how this affects the equilibrium established when chlorine is added to water.

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(2)

- (c) Explain why chlorine is used to kill bacteria in swimming pools, even though chlorine is toxic.

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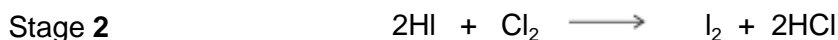
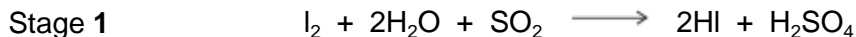
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(2)  
(Total 6 marks)

10

This question is about Group 7 chemistry.

- (a) Sea water is a major source of iodine.  
The iodine extracted from sea water is impure. It is purified in a two-stage process.



- (i) State the initial oxidation state and the final oxidation state of sulfur in Stage 1.

Oxidation state of S in  $SO_2$  .....

Oxidation state of S in  $H_2SO_4$  .....

(2)

- (ii) State, in terms of electrons, what has happened to chlorine in Stage 2.

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(1)

- (b) When concentrated sulfuric acid is added to potassium iodide, iodine is formed in the following redox equations.



- (i) Balance the equation for the reaction that forms sulfur.

(1)

- (ii) Deduce the half-equation for the formation of iodine from iodide ions.

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(1)

(iii) Deduce the half-equation for the formation of hydrogen sulfide from concentrated sulfuric acid.

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(1)

(c) A yellow precipitate is formed when silver nitrate solution, acidified with dilute nitric acid, is added to an aqueous solution containing iodide ions.

(i) Write the **simplest ionic** equation for the formation of the yellow precipitate.

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(1)

(ii) State what is observed when concentrated ammonia solution is added to this yellow precipitate.

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(1)

(iii) State why the silver nitrate solution is acidified when testing for iodide ions.

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(1)

(iv) Explain why dilute hydrochloric acid is **not** used to acidify the silver nitrate solution in this test for iodide ions.

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(1)

(d) Chlorine is toxic to humans. This toxicity does not prevent the large-scale use of chlorine in water treatment.

(i) Give **one** reason why water is treated with chlorine.

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(1)

(ii) Explain why the toxicity of chlorine does **not** prevent this use.

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(1)

(iii) Write an equation for the reaction of chlorine with cold water.

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(1)

(e) Give the formulas of the **two** different chlorine-containing compounds that are formed when chlorine reacts with cold, dilute, aqueous sodium hydroxide.

Formula 1 .....

Formula 2 .....

(1)

(Total 14 marks)