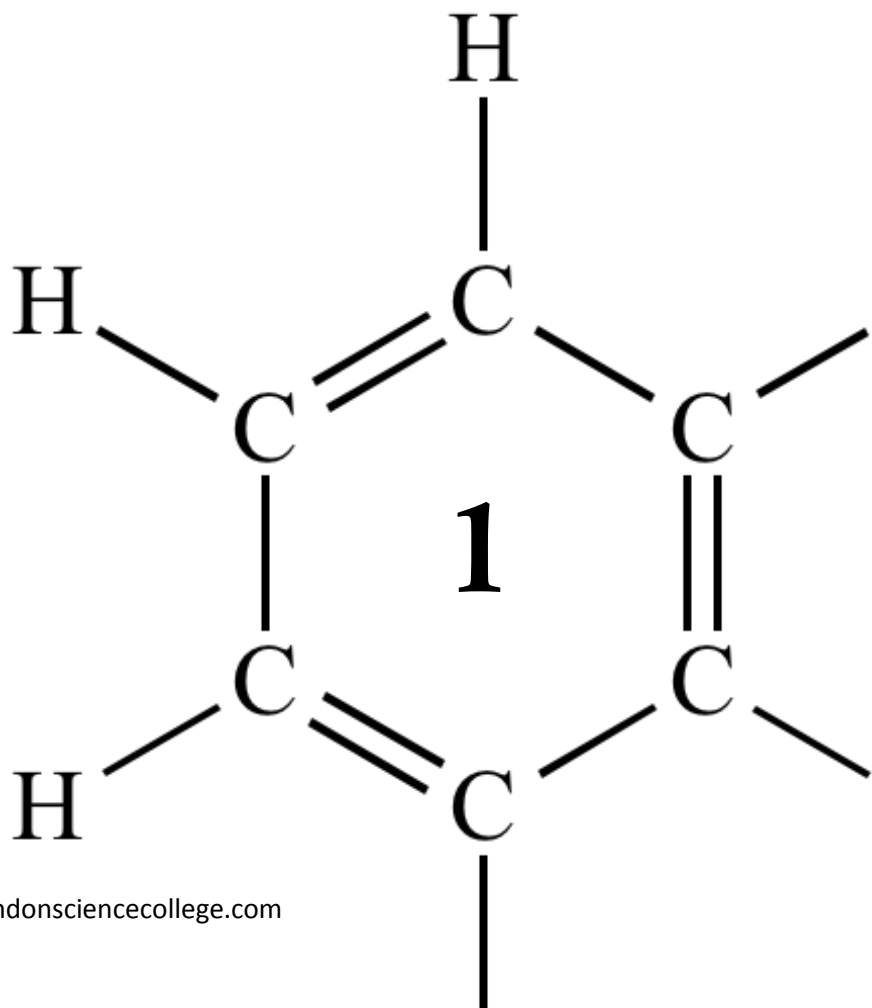


OCR AS CHEMISTRY

MODULE 2

REDOX



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

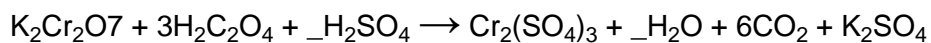
Which species contains an element with an oxidation state of +4?



(Total 1 mark)

3

Refer to the unbalanced equation below when answering this question.



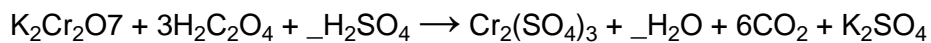
In the balanced equation the mole ratio for sulfuric acid to water is



(Total 1 mark)

4

Refer to the unbalanced equation below when answering this question.



What is the reducing agent in this reaction?



(Total 1 mark)

5

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)

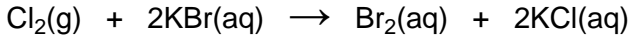
(b) The halogens can all behave as oxidising agents in reactions.

(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.

.....

(1)

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

.....

(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.

.....

(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.

.....

(1)

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

.....

(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)

6 Which of these species is the best reducing agent?

- A Cl_2
- B Cl^-
- C I_2
- D I^-

(Total 1 mark)

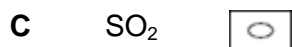
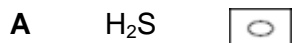
7 Which of the following shows chlorine in its correct oxidation states in the compounds shown?

	HCl	KClO ₃	HClO	
A	-1	+3	+1	<input type="checkbox"/>
B	+1	-5	-1	<input type="checkbox"/>
C	-1	+5	+1	<input type="checkbox"/>
D	+1	+5	-1	<input type="checkbox"/>

(Total 1 mark)

8

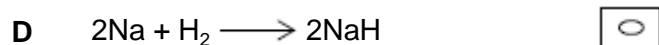
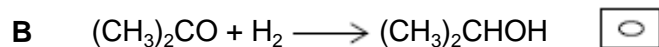
Which substance is **not** produced in a redox reaction when solid sodium iodide reacts with concentrated sulfuric acid?



(Total 1 mark)

9

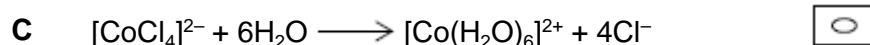
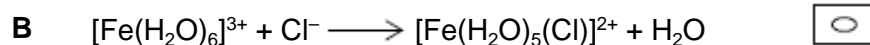
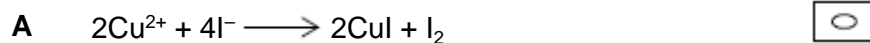
In which reaction is hydrogen acting as an oxidising agent?



(Total 1 mark)

10

In which reaction is the metal oxidised?



(Total 1 mark)

11

Chlorine is an important industrial chemical.

- (a) Chlorine is formed when 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.

.....

(1)

- (ii) Give the oxidation state of manganese in the MnO_4^- ion.

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(1)

- (iii) Deduce the half-equation for the reduction of the MnO_4^- ions in acidified solution to manganese(II) ions and water.

.....

(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

.....

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)

12

Vanadium is an important metal. Ferrovandium, an alloy of iron and vanadium, is used to make a strong type of vanadium-steel. Pure vanadium is used in nuclear reactors.

(a) The table shows some standard enthalpy of formation data.

	$V_2O_5(s)$	$CaO(s)$
$\Delta H_f^\theta / \text{kJ mol}^{-1}$	-1560	-635

In the oldest method of extraction of vanadium, V_2O_5 is reacted with calcium at a high temperature.



Use data from the table and the equation to calculate the standard enthalpy change for this reaction.

State the type of reaction that V_2O_5 has undergone.

Suggest **one** major reason why this method of extracting vanadium is expensive, other than the cost of heating the reaction mixture.

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(5)

- (b) Ferrovandium is produced by the reaction of aluminium with a mixture of V_2O_5 and iron(III) oxide.

Write an equation for the reaction of aluminium with iron(III) oxide.

State the change in oxidation state of aluminium in this reaction.

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(2)

- (c) Pure vanadium, for nuclear reactors, is formed by the reaction of hydrogen with purified VCl_2

Write an equation for this reaction in which the only other product is HCl gas.

Identify **two** hazards in this process, other than the fact that it operates at a high temperature.

Deduce why this process produces **pure** vanadium, other than the fact that purified VCl_2 is used.

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(4)
(Total 11 marks)

13

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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(2)

(Total 6 marks)

14

Antimony is a solid element that is used in industry. The method used for the extraction of antimony depends on the grade of the ore.

(a) Antimony can be extracted by reacting scrap iron with low-grade ores that contain antimony sulfide (Sb_2S_3).

(i) Write an equation for the reaction of iron with antimony sulfide to form antimony and iron(II) sulfide.

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(1)

(ii) Write a half-equation to show what happens to the iron atoms in this reaction.

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(1)

(b) In the first stage of the extraction of antimony from a high-grade ore, antimony sulfide is roasted in air to convert it into antimony(III) oxide (Sb_2O_3) and sulfur dioxide.

(i) Write an equation for this reaction.

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(1)

- (ii) Identify **one** substance that is manufactured directly from the sulfur dioxide formed in this reaction.

.....

(1)

- (c) In the second stage of the extraction of antimony from a high-grade ore, antimony(III) oxide is reacted with carbon monoxide at high temperature.

- (i) Use the standard enthalpies of formation in the table and the equation given below the table to calculate a value for the standard enthalpy change for this reaction.

	Sb₂O₃(s)	CO(g)	Sb(l)	CO₂(g)
$\Delta H_f^\ominus / \text{kJ mol}^{-1}$	-705	-111	+20	-394



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(3)

- (ii) Suggest why the value for the standard enthalpy of formation of liquid antimony, given in the table above, is **not** zero.

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(1)

- (iii) State the type of reaction that antimony(III) oxide has undergone in this reaction.

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(1)

- (d) Deduce **one** reason why the method of extraction of antimony from a low-grade ore, described in part (a), is a low-cost process. Do **not** include the cost of the ore.

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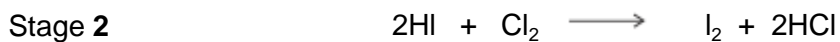
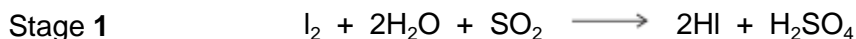
(1)

(Total 10 marks)

15

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)

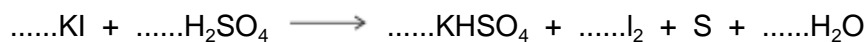
- (ii) State, in terms of electrons, what has happened to chlorine in Stage 2.

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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)