

**Q1.** Reactions that involve oxidation and reduction are used in a number of important industrial processes.

(a) Iodine can be extracted from seaweed by the oxidation of iodide ions. In this extraction, seaweed is heated with  $\text{MnO}_2$  and concentrated sulfuric acid.

(i) Give the oxidation state of manganese in  $\text{MnO}_2$

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(1)

(ii) Write a half-equation for the reaction of  $\text{MnO}_2$  in acid to form  $\text{Mn}^{2+}$  ions and water as the only products.

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(1)

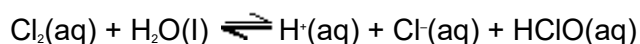
(iii) In terms of electrons, state what happens to the iodide ions when they are oxidised.

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(1)

(b) Chlorine is used in water treatment. When chlorine is added to cold water it reacts to form the acids  $\text{HCl}$  and  $\text{HClO}$ . The following equilibrium is established.



(i) Give the oxidation state of chlorine in  $\text{Cl}_2$  and in  $\text{HClO}$

$\text{Cl}_2$  .....

$\text{HClO}$  .....

(2)

(ii) Deduce what happens to this equilibrium as the  $\text{HClO}$  reacts with bacteria in the water supply. Explain your answer.

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(2)

(c) Concentrated sulfuric acid is reduced when it reacts with solid potassium bromide. Concentrated sulfuric acid is **not** reduced when it reacts with solid potassium chloride.

(i) Write the two half-equations for the following redox reaction.



Half-equation 1

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Half-equation 2

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(2)

(ii) Write an equation for the reaction of solid potassium chloride with concentrated sulfuric acid.

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(1)

(iii) Explain why chloride ions are weaker reducing agents than bromide ions.

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(2)

(Total 12 marks)

**Q2.** Chlorine is a useful industrial chemical.

(a) Chlorine gas is used in the manufacture of chlorine-containing organic compounds.

(i) Write equations for the following steps in the mechanism for the reaction of chlorine with ethane to form chloroethane ( $\text{CH}_3\text{CH}_2\text{Cl}$ ).

Initiation step

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First propagation step

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Second propagation step

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A termination step producing butane.

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**(4)**

(ii) Give **one** essential condition and name the type of mechanism in this reaction of chlorine with ethane.

Essential condition .....

Type of mechanism .....

**(2)**

(b) Chlorine reacts with cold water.

(i) Write an equation for this reaction.

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**(1)**

(ii) Give **one** large-scale application of the use of chlorine in water. Explain why it is used in this application even though chlorine is very toxic. Do **not** include cost.

Example of application.....

Explanation of use ..... (2)

(iii) Two different chlorine-containing compounds are formed when chlorine reacts with cold, dilute sodium hydroxide solution. One of these compounds is sodium chloride.

Name the other chlorine-containing compound formed.

..... (1)

(c) Chlorine is used in the extraction of bromine from seawater.

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

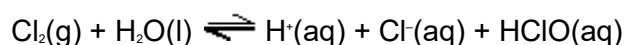
..... (1)

(ii) Explain why bromine has a higher boiling point than chlorine.

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..... (2)

(Total 13 marks)

**Q3.** (a) When chlorine gas dissolves in cold water, a pale green solution is formed. In this solution, the following equilibrium is established.



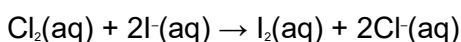
Give the formula of the species responsible for the pale green colour in the solution of chlorine in water.

Use Le Chatelier's principle to explain why the green colour disappears when sodium hydroxide solution is added to this solution.

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(3)

- (b) Consider the following reaction in which iodide ions behave as reducing agents.



In terms of electrons, state the meaning of the term *reducing agent*.

Deduce the half-equation for the conversion of chlorine into chloride ions.

Explain why iodide ions are stronger reducing agents than chloride ions.

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(4)

- (c) When chlorine reacts with water in bright sunlight, only two products are formed. One of these products is a colourless, odourless gas and the other is an acidic solution that reacts with silver nitrate solution to give a white precipitate.

Write an equation for the reaction of chlorine with water in bright sunlight.

Name the white precipitate and state what you would observe when an excess of aqueous ammonia is added to it.

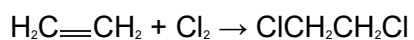
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(3)

(d) The reaction of chlorine with ethene is similar to that of bromine with ethene.

Name and outline a mechanism for the reaction of chlorine with ethene to form 1,2-dichloroethane, as shown by the following equation.



(5)  
(Total 15 marks)