

11.4 The reactions of chlorine

Name: _____ Class: _____ Date: _____

Total: 11 marks

KEY WORDS disproportionation 歧化 • water purification 水净化 • bacteria 细菌
• oxidation number 氧化数

Objective

Build the skills to answer exam questions on the **reactions of chlorine** — its **disproportionation** 歧化 with sodium hydroxide, and its use in **water purification** 水净化.

You must be able to:

- interpret chlorine's reactions with cold and hot NaOH as disproportionation
- use oxidation numbers to show the disproportionation
- explain the use of chlorine in water purification

1 Worked examples

■ Chlorine with sodium hydroxide

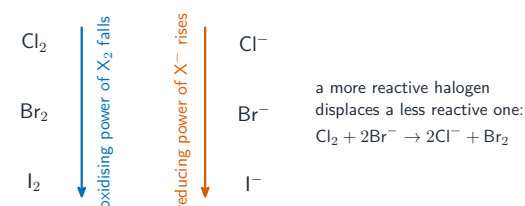
- **cold, dilute** NaOH: $\text{Cl}_2 + 2\text{NaOH} \rightarrow \text{NaCl} + \text{NaClO} + \text{H}_2\text{O}$.
- **hot, concentrated** NaOH: $3\text{Cl}_2 + 6\text{NaOH} \rightarrow 5\text{NaCl} + \text{NaClO}_3 + 3\text{H}_2\text{O}$.

Both are **disproportionation**: chlorine (0) is both oxidised (to +1 in ClO^- , or +5 in ClO_3^-) and reduced (to -1 in Cl^-).

■ Water purification



A little chlorine kills bacteria, making water safe to drink



Chlorine is a strong oxidiser in its reactions

$\text{Cl}_2 + \text{H}_2\text{O} \rightleftharpoons \text{HOCl} + \text{HCl}$. The active species **HOCl** and **ClO^-** kill **bacteria** 细菌.

2 Practice

2.1 Write the equation for chlorine reacting with cold, dilute sodium hydroxide. [1]

2.2 Name the active species, formed when chlorine reacts with water, that kills bacteria.[1]

3 Exam-style questions

3.1 Chlorine reacting with cold dilute NaOH is a disproportionation reaction because:[1]

- **A** chlorine is only oxidised
- **B** chlorine is only reduced
- **C** chlorine is both oxidised and reduced
- **D** no redox occurs

3.2 What is the oxidation number of chlorine in the chlorate(I) ion, ClO^- ? [1]

- **A** -1
- **B** 0
- **C** $+1$
- **D** $+5$

3.3 When chlorine reacts with hot concentrated sodium hydroxide:

(a) Write the equation. [2]

(b) Give the oxidation number of chlorine in each chlorine-containing product, and explain why this is disproportionation. [3]

3.4 Explain, with an equation, how chlorine makes drinking water safe. [2]

Solutions

2.1 $\text{Cl}_2 + 2\text{NaOH} \rightarrow \text{NaCl} + \text{NaClO} + \text{H}_2\text{O}$.

2.2 HOCl (chloric(I) acid) / ClO^- .

3.1 C. Chlorine is both oxidised and reduced — disproportionation.

3.2 C. Chlorine in ClO^- is $+1$.

3.3 (a) $3\text{Cl}_2 + 6\text{NaOH} \rightarrow 5\text{NaCl} + \text{NaClO}_3 + 3\text{H}_2\text{O}$.

(b) Cl in $\text{NaCl} = -1$; Cl in $\text{NaClO}_3 = +5$; chlorine starts at 0 and is both reduced (to -1) and oxidised (to $+5$).

3.4 chlorine reacts with water: $\text{Cl}_2 + \text{H}_2\text{O} \rightleftharpoons \text{HOCl} + \text{HCl}$; the HOCl/ ClO^- kills bacteria, making the water safe.