

Exercise walk-through

The reactions of chlorine ■ 11.4

eXercise

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

Method — 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 ClO₃) and reduced (to -1 in Cl).

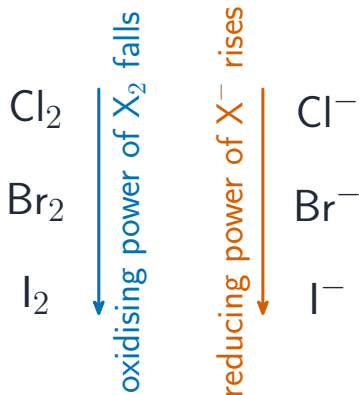
Method — Water purification

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



A swimming pool kept clean with chlorine

Method — Water purification



a more reactive halogen
displaces a less reactive one:



Chlorine is a strong oxidiser in its reactions

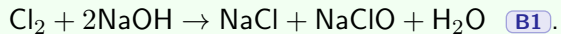
Practice 2.1 ■ 1 mark

Write the equation for chlorine reacting with cold, dilute sodium hydroxide.

Solution 2.1

Method: Chlorine with sodium hydroxide

Worked steps



Practice 2.2 ■ 1 mark

Name the active species, formed when chlorine reacts with water, that kills bacteria.

Solution 2.2

Method: Water purification

Worked steps

HOCl (chloric(I) acid) / ClO B1.

Exam-style 3.1 ■ 1 mark

Chlorine reacting with cold dilute NaOH is a disproportionation reaction because:

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

Solution 3.1

Method: Chlorine with sodium hydroxide

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

Worked steps

C. Chlorine is both oxidised and reduced — disproportionation.

Exam-style 3.2 ■ 1 mark

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

A -1

B 0

C +1

D +5

Solution 3.2

A -1

B 0

C +1



D +5

Worked steps

C. Chlorine in ClO is +1.

Exam-style 3.3 ■ 2 marks

When chlorine reacts with hot concentrated sodium hydroxide:

- (a) Write the equation.
- (b) Give the oxidation number of chlorine in each chlorine-containing product, and explain why this is disproportionation.

Solution 3.3

Method: Chlorine with sodium hydroxide

Worked steps

(a) $3\text{Cl}_2 + 6\text{NaOH} \rightarrow 5\text{NaCl} + \text{NaClO}_3 + 3\text{H}_2\text{O}$ **M1** **A1** *products, balanced.*

(b) Cl in NaCl = -1 ; Cl in NaClO = $+5$ **M1**; chlorine starts at 0 and is both reduced (to -1) and oxidised (to $+5$) **M1** **A1**.

Exam-style 3.4 ■ 2 marks

Explain, with an equation, how chlorine makes drinking water safe.

Solution 3.4

Method: Water purification

Worked steps

chlorine reacts with water: $\text{Cl}_2 + \text{H}_2\text{O} \rightleftharpoons \text{HOCl} + \text{HCl}$ **M1**; the HOCl/ClO kills bacteria, making the water safe **A1**.