Exercise walk-through

Redox processes: electron transfer and changes in oxidation number (oxidation
title_zh: 氧化还原过程：电子转移与氧化数（氧化态）的变化 state) ▪ 6.1

eXercise

You must be able to

- calculate oxidation numbers in compounds and ions
- use changes in oxidation number to balance redox equations
- explain redox, oxidation, reduction, disproportionation, and oxidising/reducing agents

Method — Oxidation number

Rules: element $= 0$; simple ion $=$ its charge; Group 1 $= +1$, Group 2 $= +2$; H $= +1$ (-1 in hydrides); O $= -2$ (-1 in peroxides); F $= -1$; sum to 0 (compound) or the charge (ion).

Method — Oxidation number

known	unknown	known
K	Mn	O_4
$+1$	$+7$	$4 \times (-2)$

they sum to 0: $(+1) + \mathrm{Mn} + (-8) = 0$, so $\mathrm{Mn} = +7$

Working out Mn in KMnO : K = +1, four O give −8, so Mn = +7

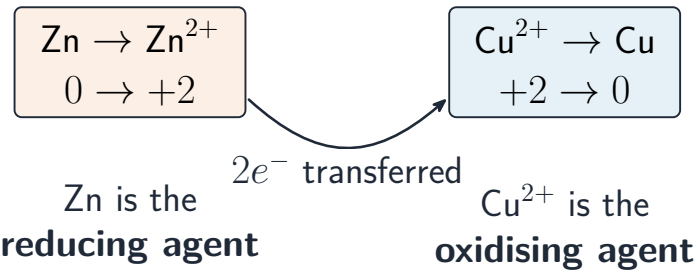
Method — Redox — OIL RIG

Oxidation = loss of electrons (number up); **reduction** = gain (number down). An **oxidising agent** takes electrons (is itself reduced); a **reducing agent** gives electrons (is itself oxidised).

Method — Redox — OIL RIG

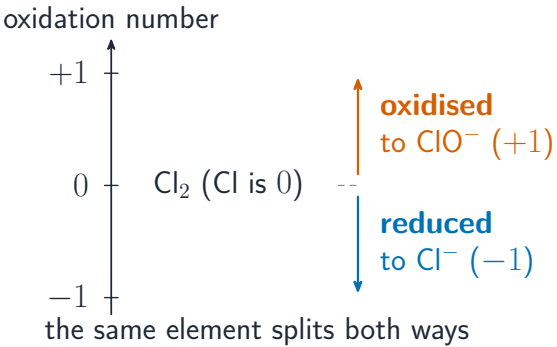
oxidation: loses $2e^-$
(oxidation number ↑)

reduction: gains $2e^-$
(oxidation number ↓)



Zinc loses 2 electrons to become Zn^2 while Cu^2 gains them to become copper

Method — Disproportionation



A line showing chlorine at 0 going up to +1 in ClO and down to −1 in Cl

Practice 2.1 ▪ 2 marks

Calculate the oxidation number of (a) S in SO_4^{2-} and (b) N in NO_3^-.

Solution 2.1

Worked steps

(a) S: $x + 4(-2) = -2 \Rightarrow x = +6$ B1; (b) N: $x + 3(-2) = -1 \Rightarrow x = +5$ B1.

Practice 2.2 ▪ 2 marks

Complete: “Oxidation is the ____ of electrons; the oxidation number goes ____.”

Solution 2.2

Method: Redox — OIL RIG

Worked steps

loss; up B1 *each*.

Exam-style 3.1 ▪ 1 mark

What is the oxidation number of chromium in $Cr_2O_7^{2-}$?

A $+3$

B $+6$

C $+7$

D $+12$

Solution 3.1

A $+3$

B $+6$ ✓

C $+7$

D $+12$

Worked steps

B. $2x + 7(-2) = -2 \Rightarrow 2x = 12 \Rightarrow x = +6$.

Exam-style 3.2 ▪ 1 mark

In the reaction $\mathrm{Zn} + \mathrm{Cu}^{2+} \rightarrow \mathrm{Zn}^{2+} + \mathrm{Cu}$, the reducing agent is:

A Zn

B Cu^{2}

C Zn^{2}

D Cu

Solution 3.2

Method: Redox — OIL RIG

A Zn ✓

B Cu^2

C Zn^2

D Cu

Worked steps

A. Zn loses electrons (is oxidised), so it is the reducing agent.

Exam-style 3.3 ▪ 3 marks

When chlorine reacts with cold water it forms Cl and ClO .
(a) State the oxidation number of chlorine in Cl_2, in Cl^- and in ClO^-.
(b) Explain why this is a disproportionation reaction.

Solution 3.3

Worked steps

(a) $Cl_2 = 0$; $Cl^- = -1$; $ClO^- = +1$ **B1** *each*.
(b) the same element (chlorine) is both oxidised ($0 \to +1$) and reduced ($0 \to -1$) in one reaction **M1** **A1**.

Exam-style 3.4 ▪ 2 marks

In acidic solution, MnO_4^- (Mn $= +7 \rightarrow +2$) oxidises Fe^{2+} ($\rightarrow$ Fe^3). Use oxidation-number changes to deduce the ratio of MnO_4^- to Fe^{2+}.

Solution 3.4

Worked steps

Mn falls by 5 ($+7 \to +2$); Fe rises by 1 ($+2 \to +3$) M1; so 5 Fe^{2} are needed per MnO_4^- — ratio 1 : 5 A1.