A-LEVEL CHEMISTRY • EXERCISE SHEET

6.1 Redox processes: electron transfer and oxidation number

Name: ____________ Class: ________ Date: __________ **Total: 25 marks**

KEY WORDS oxidation 氧化 • oxidation number 氧化数 • oxidising agent 氧化剂 • redox 氧化还原 • reducing agent 还原剂

Objective

Build the skills to answer exam questions on **redox processes** 氧化还原过程 — **oxidation numbers** 氧化数, electron transfer, **disproportionation** 歧化, and **oxidising/reducing agents** 氧化剂/还原剂.

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

1 Worked examples

Oxidation number

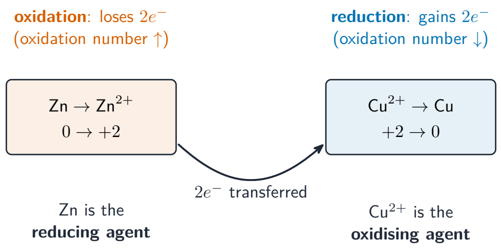
Rules: element = 0; simple ion = its charge; Group 1 = +1, Group 2 = +2; H = +1 (−1 in hydrides); O = −2 (−1 in peroxides); F = −1; sum to 0 (compound) or the charge (ion).

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

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

Fix the known atoms, then use "they sum to zero" to find the unknown (Mn = +7)

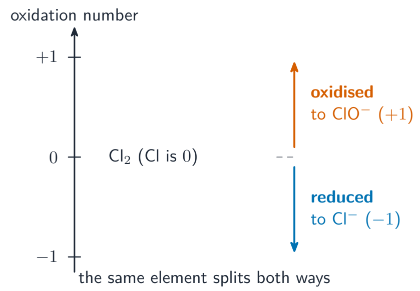
Redox — OIL RIG



Oxidation Is Loss, Reduction Is Gain. The reducing agent is oxidised; the oxidising agent is reduced

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).

Disproportionation



The same element is both oxidised and reduced: Cl (0) → ClO^- (+1) and Cl^- (−1)

2 Practice

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

2.2 Complete: “Oxidation is the _____ of electrons; the oxidation number goes _____.” [2]

3 Exam-style questions

3.1 What is the oxidation number of chromium in $Cr_2O_7^{2-}$? [1]

- **A** +3
- **B** +6
- **C** +7
- **D** +12

3.2 In the reaction $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$, the reducing agent is: [1]

- **A** Zn
- **B** Cu^{2+}
- **C** Zn^{2+}
- **D** Cu

3.3 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^-. [3]

(b) Explain why this is a disproportionation reaction. [2]

3.4 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+}. [2]

3.5 Chlorine reacts with **cold dilute** sodium hydroxide:

$$Cl_2 + 2NaOH \rightarrow NaCl + NaClO + H_2O$$

(a) Give the oxidation number of chlorine in Cl_2, in NaCl and in NaClO. [3]

(b) Explain why this reaction is described as disproportionation. [2]

(c) With **hot concentrated** sodium hydroxide the products are NaCl and $NaClO_3$. Write the balanced equation and show that this reaction is also disproportionation. [4]

(d) Chlorine also displaces iodine from aqueous potassium iodide. Write the ionic equation, and identify the oxidising agent, explaining your choice. [3]

Solutions

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

2.2 loss; up.

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

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

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

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

3.5 (a) Cl_2: 0; NaCl: -1; NaClO: $+1$. In NaClO, Na is $+1$ and O is -2, so Cl must be $+1$.
(b) The **same** element is oxidised and reduced in the one reaction: chlorine goes $0 \to +1$ in NaClO and $0 \to -1$ in NaCl.
(c) $3Cl_2 + 6NaOH \to 5NaCl + NaClO_3 + 3H_2O$. Five chlorine atoms fall $0 \to -1$ (gaining 5 electrons in total) while one rises $0 \to +5$ (losing 5); the electrons balance, and again one element is both oxidised and reduced.
(d) $Cl_2 + 2I^- \to 2Cl^- + I_2$. Chlorine is the oxidising agent: it **gains** electrons ($0 \to -1$), i.e. it is itself reduced while oxidising the iodide.