Week 9

A-Level Chemistry

Homework bundle for this week

本周作业合集

exercises.lol

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A-Level Chemistry Name: _____ Score: _____

1. The oxidation number of an uncombined element (like O_2 or Fe) is:

   ☐ 0

   ☐ +1

   ☐ −2

   ☐ equal to its group

2. When balancing a redox equation using oxidation numbers:

   ☐ the total rise in oxidation number must equal the total fall

   ☐ the rise is always bigger than the fall

   ☐ oxidation numbers are ignored

   ☐ only the masses matter

3. The usual oxidation number of oxygen in a compound is:

   ☐ −2 (but −1 in peroxides)

   ☐ +2

   ☐ 0

   ☐ +6

4. Disproportionation is a reaction in which:

   ☐ the same element is both oxidised and reduced

   ☐ two different elements are oxidised

   ☐ no electrons move

   ☐ only reduction happens

5. In $KMnO_4$, K is +1 and each O is −2. What is the oxidation number of Mn? (give the number, e.g. 7)

   _____

6. An oxidising agent:

   ☐ takes electrons from another species and is itself reduced

   ☐ gives electrons away and is itself oxidised

   ☐ does not take part in redox

   ☐ always contains oxygen

7. A substance that loses electrons in a reaction is being _____.

_____

8. An oxidising agent is itself reduced during a reaction.

   ☐ True ☐ False

9. Using OIL RIG, oxidation is:

   ☐ loss of electrons (oxidation number goes up)

   ☐ gain of electrons

   ☐ gain of protons

   ☐ loss of neutrons

10. A reducing agent:

    ☐ gives electrons to another species and is itself oxidised

    ☐ takes electrons and is itself reduced

    ☐ cannot change oxidation number

    ☐ always contains hydrogen

6. Electrochemistry

Answers · 答案

A-Level Chemistry

1. **0**

   A free, uncombined element always has an oxidation number of 0.

2. **the total rise in oxidation number must equal the total fall**

   Every electron lost is gained, so the total increase in oxidation number equals the total decrease.

3. **−2 (but −1 in peroxides)**

   Oxygen is normally −2, except −1 in peroxides.

4. **the same element is both oxidised and reduced**

   In disproportionation one element goes both up and down in oxidation number (e.g. $Cl_2 \rightarrow Cl^-$ and ClO^-).

5. **7**

   +1 (K) + Mn + 4×(−2) = 0, so Mn = +7.

6. **takes electrons from another species and is itself reduced**

   An oxidising agent removes electrons from another species, so it gains electrons and is reduced itself.

7. **oxidised**

   OIL: Oxidation Is Loss of electrons.

8. **True**

   It gains the electrons lost by the other species.

9. **loss of electrons (oxidation number goes up)**

   Oxidation Is Loss of electrons; the oxidation number rises. Reduction Is Gain (number falls).

10. **gives electrons to another species and is itself oxidised**

    A reducing agent donates electrons, causing reduction of the other species while being oxidised itself.

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

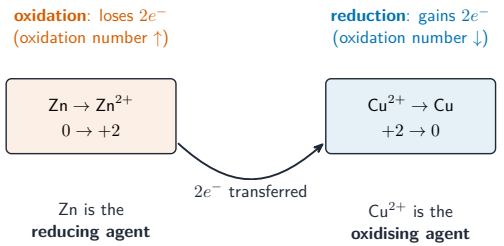
Rules: element = 0; simple ion = its charge; Group 1 = +1, Group 2 = +2; H = +1 (−1 in hydrides); O = −2 (−1 in peroxides); F = −1; sum to 0 (compound) or the charge (ion).

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

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

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

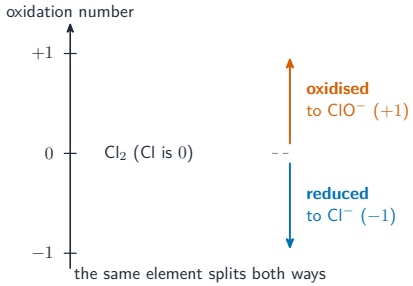
Redox — OIL RIG



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 → +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 ($0 \rightarrow +1$) and reduced ($0 \rightarrow -1$) in one reaction.

3.4 Mn falls by 5 ($+7 \rightarrow +2$); Fe rises by 1 ($+2 \rightarrow +3$); 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 $0 \rightarrow +1$ in NaClO and $0 \rightarrow -1$ in NaCl.
(c) $3Cl_2 + 6NaOH \rightarrow 5NaCl + NaClO_3 + 3H_2O$. Five chlorine atoms fall $0 \rightarrow -1$ (gaining 5 electrons in total) while one rises $0 \rightarrow +5$ (losing 5); the electrons balance, and again one element is both oxidised and reduced.
(d) $Cl_2 + 2I^- \rightarrow 2Cl^- + I_2$. Chlorine is the oxidising agent: it **gains** electrons ($0 \rightarrow -1$), i.e. it is itself reduced while oxidising the iodide.

9 Sulfite ions, SO_3^{2-}, react separately with zinc and with manganese dioxide.

a, *b*, *c*, *d*, *w*, *x*, *y* and *z* are all whole numbers.

$$a SO_3^{2-}(aq) + b H_2O(l) + Zn(s) \rightarrow Zn^{2+}(aq) + c OH^-(aq) + d S_2O_4^{2-}(aq)$$

$$MnO_2(s) + w SO_3^{2-}(aq) + x H^+(aq) \rightarrow Mn^{2+}(aq) + y S_2O_6^{2-}(aq) + z H_2O(l)$$

Which numbers are correct for *a*, *b*, *w* and *x*?

	a	*b*	*w*	*x*
A	1	2	2	4
B	2	2	2	4
C	1	2	4	2
D	2	2	4	2

10 Which equation shows hydrogen acting as an oxidising agent?

A $H_2 + 2K \rightarrow 2K^+H^-$

B $H_2 + I_2 \rightarrow 2HI$

C $H_2 + Cu_2S + ZnO \rightarrow 2Cu + ZnS + H_2O$

D $3H_2 + N_2 \rightarrow 2NH_3$

3 The reaction of hydrogen sulfide with sulfur dioxide gives sulfur as one of the products.

The two relevant redox equations are shown.

$$H_2S(aq) \rightleftharpoons S(s) + 2H^+(aq) + 2e^-$$

$$SO_2(aq) + 4H^+(aq) + 4e^- \rightleftharpoons S(s) + 2H_2O(l)$$

How many moles of hydrogen sulfide are needed to react with sulfur dioxide to produce 1 mol of sulfur?

A $\frac{1}{3}$ mol **B** $\frac{2}{3}$ mol **C** $\frac{3}{2}$ mol **D** 2 mol

11 In which substance is the average oxidation number of sulfur the highest?

A S_8 **B** $Na_2S_4O_6$ **C** $Na_2S_2O_3$ **D** SO_2Cl_2

11 Acidified potassium manganate(VII) reacts with iron(II) ethanedioate, FeC_2O_4.

The reactions taking place are shown.

$$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$$

$$Fe^{2+} \rightarrow Fe^{3+} + e^-$$

$$C_2O_4^{2-} \rightarrow 2CO_2 + 2e^-$$

How many moles of iron(II) ethanedioate react with **one** mole of potassium manganate(VII)?

A 0.60 **B** 1.67 **C** 2.50 **D** 5.00

1 Manganese, Mn, and its compounds are widely used in many chemical reactions.

(a) Mn is usually found as a single isotope, manganese-55.

(i) Determine the number of protons, neutrons and electrons in an atom of manganese-55.

number of protons ..... neutrons ..... electrons .....
[1]

(ii) Define isotopes.

.....

..... [1]

(iii) A sample of manganese from the Moon is found to contain manganese-53 in addition to manganese-55.

State the two pieces of information needed to determine the relative atomic mass, A_r, of manganese in this sample.

1 .....

2 .....
[2]

(b) The shorthand electronic configuration of manganese is [Ar] $3d^5\ 4s^2$.

(i) Complete the full electronic configuration of manganese.

..... $3d^5\ 4s^2$ [1]

(ii) Deduce the total number of unpaired electrons in an atom of manganese.

.... [1]

(c) Manganese(IV) oxide reacts with methanal, CH_2O, in acidic conditions to produce carbon dioxide. The movement of electrons to or from relevant species is shown in the following half-equations.

half-equation 1 $CH_2O + H_2O \rightarrow CO_2 + 4H^+ + 4e^-$

half-equation 2 $MnO_2 + 4H^+ + 2e^- \rightarrow Mn^{2+} + 2H_2O$

(i) Identify the species that is reduced in half-equation 2. Explain your answer.

.....

..... [1]

(ii) The oxidation state of carbon in methanal is 0.

Calculate the oxidation state of carbon in carbon dioxide.

..... [1]

(iii) Construct the ionic equation for the reaction of manganese(IV) oxide with methanal in acidic conditions.

..... [2]

[Total: 10]

1 Iron is an element that is essential in the human diet. Some people need to take iron supplement tablets to ensure an adequate intake of iron.

You will investigate the mass of iron in an iron supplement tablet by titrating a solution with potassium manganate(VII).

$$Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + e^-$$

$$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$$

FB 1 is an aqueous solution of iron supplement tablets made by dissolving 14 tablets in 1.00 dm^3 of solution. The iron in each tablet is iron(II) sulfate, $FeSO_4 \bullet 7H_2O$.
FB 2 is 0.0100 mol dm^{-3} acidified aqueous potassium manganate(VII), $KMnO_4$.
FB 3 is dilute sulfuric acid, H_2SO_4.

(a) Method

- Fill a burette with **FB 2**.
- Pipette 25.0 cm^3 of **FB 1** into a conical flask.
- Use the 25 cm^3 measuring cylinder to add 10.0 cm^3 of **FB 3** to the conical flask.
- Perform a rough titration and record your burette readings in the space below.

The rough titre is ..... cm^3.

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make sure any recorded results show the precision of your practical work.
- Record, in a suitable form in the space below, all your burette readings and the volume of **FB 2** added in each accurate titration.

Rinse the burette with distilled water and leave to drain while you continue Question 1.

Results

I	
II	
III	
IV	
V	
VI	
VII	

[7]

(b) From your accurate titration results, calculate a suitable mean value to use in your calculations. Show clearly how you obtain the mean value.

25.0 cm^3 of **FB 1** required ..... cm^3 of **FB 2**. [1]

(c) Calculations

(i) Give your answers to **(c)(ii)**, **(c)(iii)** and **(c)(iv)** to an appropriate number of significant figures. [1]

(ii) Calculate the amount, in mol, of manganate(VII) ions in the volume of **FB 2** in **(b)**.

amount of MnO_4^- = ... mol [1]

(iii) Use your answer to **(c)(ii)** and the equations at the start of the question to calculate the concentration, in mol dm^{-3}, of iron(II) ions in **FB 1**.

concentration of Fe^{2+} = ... mol dm^{-3} [1]

(iv) Use your answer to **(c)(iii)** to calculate the concentration, in g dm^{-3}, of iron(II) ions in **FB 1**.

concentration of Fe^{2+} = ... g dm^{-3} [1]

(v) The manufacturer of the iron supplement tablets used to make **FB 1** claims that each tablet contains a minimum of 150 mg of Fe^{2+}.

Use your answer to **(c)(iv)** and the information given about **FB 1** to determine whether this claim is correct. Show your working.

[1]

(d) A student used all the **FB 3** and suggests that dilute hydrochloric acid would be a suitable replacement.
Suggest whether the student is correct or not. Explain your answer.

.....

.....

..... [1]

[Total:14]