Metal oxides

4.4.1.1 · Chemical changes · revision notes

How metals react with oxygen to form metal oxides, and what oxidation and reduction mean in terms of oxygen. Expect word equations, balancing symbol equations and short questions asking which substance is oxidised or reduced, with a reason.

Key facts

- metal + oxygen → metal oxide
- Oxidation = gain of oxygen
- Reduction = loss of oxygen
- Redox = oxidation and reduction in the same reaction
- $2Mg + O_2 \rightarrow 2MgO$
- $4Na + O_2 \rightarrow 2Na_2O$
- $2Cu + O_2 \rightarrow 2CuO$ (black copper(II) oxide)
- Oxide ion: O^{2-}

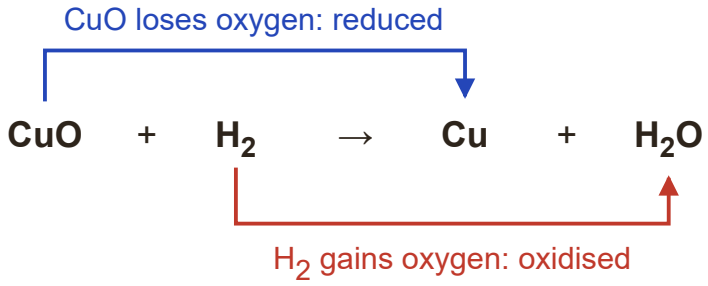
Notes

Metals reacting with oxygen

- Many metals react with **oxygen** (for example in the air) to produce a **metal oxide**.
- Word equation: metal + oxygen → metal oxide, e.g. magnesium + oxygen → magnesium oxide.
- Symbol equation: $2Mg + O_2 \rightarrow 2MgO$. Oxygen gas is always O_2, so you often need a 2 in front of the oxide.
- More reactive metals react with oxygen more quickly: freshly cut sodium goes dull within seconds, but copper only reacts noticeably when heated, forming black copper(II) oxide.
- Gold does not react with oxygen, which is why it stays shiny.

Oxidation and reduction in terms of oxygen

- **Oxidation** is the **gain of oxygen**. A metal that reacts with oxygen is oxidised.
- **Reduction** is the **loss of oxygen**. A metal oxide that loses its oxygen to form the metal is reduced.
- When a metal oxide is reduced, the oxygen it loses is gained by another substance, which is oxidised. A reaction in which oxidation and reduction both happen is a **redox** reaction.
- Example: copper(II) oxide + hydrogen → copper + water. Copper(II) oxide loses oxygen, so it is reduced. Hydrogen gains oxygen, so it is oxidised.



Follow the oxygen: the substance that loses it is reduced, the one that gains it is oxidised.

- Example: $2PbO + C \rightarrow 2Pb + CO_2$. Lead(II) oxide is reduced; carbon is oxidised.

Writing formulae and balancing

- The oxide ion is O^{2-}. Balance the charges to get the formula: Na^+ gives Na_2O, Mg^{2+} gives MgO, Al^{3+} gives Al_2O_3.
- Balance an equation by putting numbers in front of formulae. Never change the small numbers inside a formula.
- Examples: $4Na + O_2 \rightarrow 2Na_2O$ and $4Al + 3O_2 \rightarrow 2Al_2O_3$.
- Check by counting every atom of each element on both sides.

How to answer each type of question

Write a word or balanced symbol equation

1 to 3 marks | Grade 4

1. Name the product: metal + oxygen gives the metal oxide.
2. For a symbol equation, write the correct formulae first (oxygen is O_2).
3. Balance with numbers in front of formulae, then count every atom on both sides.

Example. Calcium burns in oxygen to form calcium oxide.
(a) Write a word equation for this reaction.
(b) Write a balanced symbol equation for this reaction.

Model answer.

(a) calcium + oxygen → calcium oxide (1)

(b) Correct formulae: $Ca + O_2 \rightarrow CaO$ (1)

Balanced: $2Ca + O_2 \rightarrow 2CaO$ (1)

Which substance is reduced (or oxidised)? Give a reason

2 marks | Grade 5

1. Find the substance that loses oxygen: it is reduced.
2. Find the substance that gains oxygen: it is oxidised.
3. Give the reason using the words 'loses oxygen' or 'gains oxygen'.

Example. Hot iron(III) oxide reacts with carbon monoxide:
$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$
Which substance is reduced? Give a reason for your answer.

Model answer.

Iron(III) oxide (1)

It loses oxygen (to form iron) (1)

Explain why a reaction is a redox reaction 2 marks **Grade 5**

1. Name the substance that gains oxygen and say it is oxidised.
2. Name the substance that loses oxygen and say it is reduced.
3. Make clear both happen in the same reaction.

Example. Heated lead(II) oxide reacts with hydrogen:
$PbO + H_2 \rightarrow Pb + H_2O$

Explain why this is a redox reaction.

Model answer.

Hydrogen gains oxygen (to form water), so hydrogen is oxidised (1)

Lead(II) oxide loses oxygen (to form lead), so it is reduced (1)

Don't lose marks

- Writing oxygen as O instead of O_2 in a symbol equation.
- Changing a formula to balance an equation, e.g. writing MgO_2.
- Naming the substance that is reduced but not giving the reason (loses oxygen), which loses the second mark.
- Saying the oxide is oxidised: an oxide that becomes a metal has lost oxygen, so it is reduced.

More tips

Memory tricks

- Oxidation has 'oxygen' in its name: oxidation = oxygen added.
- An oxide that turns into an element has been 'reduced' down to the bare element: it lost oxygen.
- Oxygen gas is O_2, so metal oxide equations nearly always need a 2 (or 4) somewhere: 2Mg, 4Na, 4Al.

Exam technique

- When a question says 'give a reason', always use 'gains oxygen' or 'loses oxygen'.
- Name the whole substance, e.g. 'copper(II) oxide is reduced', not just 'copper'.
- Only add state symbols if the question asks for them.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 **Name the oxide formed by a metal**
A metal reacting with oxygen forms the metal oxide, e.g. magnesium + oxygen → magnesium oxide.

Grade 4 **Define oxidation and reduction using oxygen**
Oxidation is the gain of oxygen and reduction is the loss of oxygen.

Grade 5 **Identify what is oxidised or reduced**

In an equation, the substance that gains oxygen is oxidised and the substance that loses oxygen is reduced.

Grade 5

Explain why a reaction is a redox reaction

Show that one substance gains oxygen while another loses oxygen in the same reaction.

Grade 6

Balance equations for metals reacting with oxygen

Write correct formulae first, then balance with numbers in front, e.g. $4Na + O_2 \rightarrow 2Na_2O$.

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