Cambridge IGCSE · Chemistry 0620 · Notes

Redox

Read online at **pastopic.com/cambridge/chemistry-0620/notes/redox**

Last checked 29 September 2026

Read first: **Formulae and equations**, **Ionic and metallic bonding**

What you need to know

By the end of this topic you should be able to:

1. **Read and use a Roman numeral in a name.** In iron(III) oxide the (III) is the **oxidation number** of iron, $+3$.
2. **State what a redox reaction is**: one where **oxidation and reduction happen at the same time**.
3. **Define oxidation as gain of oxygen and reduction as loss of oxygen.**
4. **Identify redox reactions** as reactions where one substance gains oxygen and another loses it.
5. **Pick out what is oxidised and what is reduced** in a redox reaction.
6. **Extended only:** define oxidation as **loss of electrons** or an **increase in oxidation number**.
7. **Extended only:** define reduction as **gain of electrons** or a **decrease in oxidation number**.
8. **Extended only:** identify redox reactions as reactions where electrons are lost and gained.
9. **Extended only:** work out oxidation numbers with four rules (an uncombined element is 0; a monatomic ion equals its charge; a compound adds up to 0; an ion adds up to its charge), and use changes in them to spot redox reactions.
10. **Extended only:** identify redox reactions from the colour changes of **acidified aqueous potassium manganate(VII)** and **aqueous potassium iodide**.
11. **Extended only:** define an **oxidising agent**: a substance that oxidises another substance and is itself reduced.
12. **Extended only:** define a **reducing agent**: a substance that reduces another substance and is itself oxidised.
13. **Extended only:** identify the oxidising agent and the reducing agent in a redox reaction.

Understand it

Oxidation and reduction with oxygen (Core)

When magnesium burns, it joins with oxygen to make magnesium oxide. Magnesium has **gained oxygen**: it has been **oxidised**. When hydrogen is passed over hot copper(II) oxide, the oxide turns into copper. Copper(II) oxide has **lost oxygen**: it has been **reduced**.

$$\mathrm{CuO} + \mathrm{H_2} \rightarrow \mathrm{Cu} + \mathrm{H_2O}$$

Look at where the oxygen goes. It leaves the copper(II) oxide and joins the hydrogen. So in this one reaction copper(II) oxide is reduced **and** hydrogen is oxidised. Oxygen cannot be lost unless something else takes it, so oxidation and reduction always happen **together**. A reaction in which both happen at the same time is a **redox** reaction (**red**uction + **ox**idation).

To decide which is which, follow the oxygen from left to right in the equation:

- the substance on the **left** that **loses** oxygen is **reduced** (here CuO);
- the substance on the **left** that **gains** oxygen is **oxidised** (here $\mathrm{H_2}$).

The answer is always a **reactant**, the whole substance: "copper(II) oxide is reduced", not "copper is reduced" (copper is the product).

Common redox reactions you will meet:

- **Burning** (combustion): the fuel gains oxygen. Complete and incomplete combustion are both redox.
- **Rusting**: iron gains oxygen to form hydrated iron(III) oxide.
- **Extracting a metal from its oxide** with carbon, carbon monoxide or hydrogen: the metal oxide is reduced, and the carbon, carbon monoxide or hydrogen is oxidised.
- **A more reactive metal heated with the oxide of a less reactive metal**, such as $\mathrm{Mg} + \mathrm{CuO} \rightarrow \mathrm{MgO} + \mathrm{Cu}$: the reactive metal is oxidised and the oxide is reduced.

Reactions where nothing is oxidised or reduced are **not** redox: neutralisation (acid + base or alkali), an acid with a carbonate, precipitation (such as $\mathrm{Ag^+} + \mathrm{Cl^-} \rightarrow \mathrm{AgCl}$), and thermal decomposition of a carbonate ($\mathrm{CaCO_3} \rightarrow \mathrm{CaO} + \mathrm{CO_2}$: the oxygen just changes partners, and every element keeps its oxidation number).

Roman numerals in names (Core)

Some metals, especially transition elements, form more than one ion. The Roman numeral in the name tells you the **oxidation number of that element** in the compound:

- iron(II) chloride, $\mathrm{FeCl_2}$: iron is $+2$; iron(III) chloride, $\mathrm{FeCl_3}$: iron is $+3$;
- copper(II) oxide, CuO: copper is $+2$;
- potassium manganate(VII), $\mathrm{KMnO_4}$: **manganese** is $+7$ (the numeral goes after the part it belongs to).

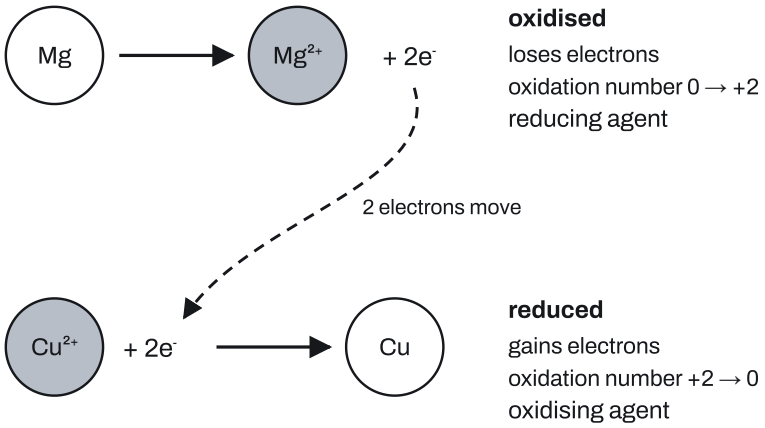
The numeral is **not** the charge on the whole compound, a number of atoms, or an amount of energy. You can use it to write a formula: manganese(IV) oxide has Mn at $+4$ and each O at -2, so it needs two oxygens: $\mathrm{MnO_2}$.

Oxidation and reduction with electrons (Extended)

Many redox reactions have no oxygen in them at all, so a wider definition is used. When magnesium is added to copper(II) sulfate solution, the blue colour fades and brown copper forms:

$$\mathrm{Mg(s)} + \mathrm{Cu^{2+}(aq)} \rightarrow \mathrm{Mg^{2+}(aq)} + \mathrm{Cu(s)}$$

Each magnesium atom **loses two electrons** and becomes Mg^{2+}; each Cu^{2+} ion **gains** those two electrons and becomes a copper atom. The electrons pass from the magnesium to the copper ions.



- **Oxidation is loss of electrons.** Magnesium is oxidised.
- **Reduction is gain of electrons.** Copper(II) ions are reduced.

A memory aid: **OIL RIG**, **O**xidation **I**s **L**oss, **R**eduction **I**s **G**ain (of electrons). The electrons lost always equal the electrons gained, which is why oxidation and reduction always come together.

This fits the oxygen definition too. In $2\mathrm{Mg} + \mathrm{O_2} \rightarrow 2\mathrm{MgO}$, magnesium atoms lose electrons to become Mg^{2+} and oxygen atoms gain them to become O^{2-}.

Oxidation numbers (Extended)

An **oxidation number** is a number with a sign, given to each atom, that shows how many electrons it has lost ($+$) or gained ($-$) compared with the uncombined element. Work it out with four rules:

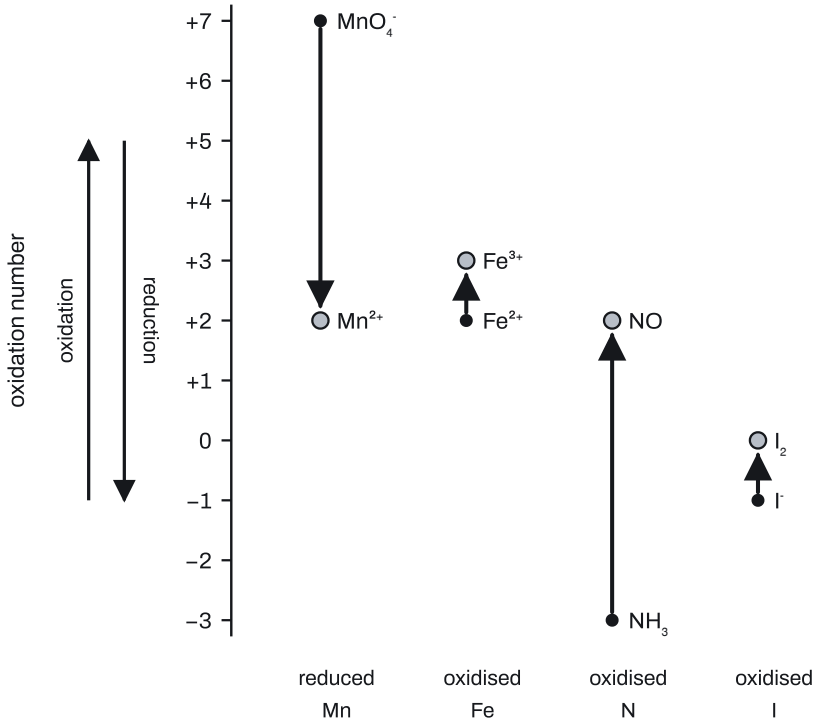
1. An element on its own (uncombined) is 0: Fe, $\mathrm{O_2}$, $\mathrm{Cl_2}$, $\mathrm{I_2}$, $\mathrm{N_2}$.
2. A monatomic (one-atom) ion equals its charge: Fe^{3+} is $+3$, Cl^{-} is -1, O^{2-} is -2.
3. The oxidation numbers in a **compound** add up to 0.
4. The oxidation numbers in an **ion** add up to the **charge on the ion**.

Oxygen in compounds is almost always -2 (questions usually tell you). Hydrogen joined to a non-metal is $+1$, Group I metals in compounds are $+1$, Group II metals are $+2$, and a halogen in a metal halide is -1. Use these to find the one unknown.

For example, sulfur in the sulfate ion, $\mathrm{SO_4^{2-}}$: let sulfur be x. Then $x + 4(-2) = -2$, so $x = +6$. Nitrogen in ammonia, $\mathrm{NH_3}$: $x + 3(+1) = 0$, so $x = -3$.

Always write the sign, even for a positive number: $+6$, not 6.

Increase in oxidation number = oxidation. Decrease in oxidation number = reduction. Losing electrons (negative) makes the number go up; gaining them makes it go down.



To test whether any reaction is redox, find the oxidation number of each element on both sides. If any element changes, it is redox. In $\mathrm{NaOH + HCl \rightarrow NaCl + H_2O}$ nothing changes (Na $+1$, O -2, H $+1$, Cl -1 on both sides), so it is not redox.

One element can even be oxidised and reduced in the same reaction: in $\mathrm{C + CO_2 \rightarrow 2CO}$, carbon goes from 0 up to $+2$ (oxidised) and from $+4$ in $\mathrm{CO_2}$ down to $+2$ (reduced).

Oxidising agents and reducing agents (Extended)

An **oxidising agent** oxidises something else, by taking its electrons, so it is **itself reduced**. A **reducing agent** reduces something else, by giving it electrons, so it is **itself oxidised**.

	Oxidising agent	Reducing agent
Does this to the other substance	oxidises it	reduces it
Electrons	gains them	loses them
Its oxidation number	decreases	increases
What happens to it	is reduced	is oxidised

So the substance that is reduced **is** the oxidising agent, and the substance that is oxidised **is** the reducing agent. In $\mathrm{Mg + Cu^{2+}}$, $\mathrm{Cu^{2+}}$ is the oxidising agent and Mg is the reducing agent. In the blast furnace, $\mathrm{Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2}$, carbon monoxide is the reducing agent. Name the reactant, not the product: iron(III) oxide (not iron) is the oxidising agent.

Common oxidising agents: oxygen, chlorine, bromine, acidified potassium manganate(VII), $\mathrm{Fe^{3+}}$. Common reducing agents: carbon, carbon monoxide, hydrogen, reactive metals, iodide ions, $\mathrm{Fe^{2+}}$.

Two colour tests for redox (Extended)

- **Acidified aqueous potassium manganate(VII)** is an **oxidising agent**. It is **purple**. When it oxidises something (a reducing agent such as Fe^{2+}, iodide ions, sulfite ions or ethanol), it is reduced to Mn^{2+} and the solution turns **from purple to colourless**. It must be **acidified**. If there is no reducing agent, it stays purple (or pink when only a few drops are added).
- **Aqueous potassium iodide** is a **reducing agent**. It is **colourless**. When an oxidising agent (such as chlorine, bromine or Fe^{3+}) oxidises the iodide ions, **iodine** forms and the solution turns **from colourless to brown**. If there is no oxidising agent, it stays colourless.

So manganate(VII) going colourless shows a **reducing agent** is present; iodide turning brown shows an **oxidising agent** is present.

Key facts and formulas

"Given" means the exam paper prints it. "Learn it" means you must remember it. Chemistry 0620 has no formula sheet, so everything here must be learned.

Formula	Status
Oxidation = gain of oxygen; reduction = loss of oxygen	Learn it
Redox = oxidation and reduction happening at the same time	Learn it
Roman numeral = oxidation number of that element, e.g. iron(III) → Fe is $+3$	Learn it
Extended only: oxidation = loss of electrons = increase in oxidation number	Learn it
Extended only: reduction = gain of electrons = decrease in oxidation number	Learn it
Extended only: uncombined element $= 0$; monatomic ion $=$ its charge; compound sums to 0; ion sums to its charge	Learn it
Extended only: O is -2 in compounds (usually); H $+1$ with non-metals; Group I $+1$; Group II $+2$; halide -1	Learn it
Extended only: oxidising agent oxidises another substance and is itself reduced (gains electrons)	Learn it
Extended only: reducing agent reduces another substance and is itself oxidised (loses electrons)	Learn it
Extended only: acidified $\mathrm{KMnO_4}$: purple → colourless with a reducing agent	Learn it

Formula	Status
Extended only: aqueous KI: colourless → brown (iodine) with an oxidising agent	Learn it

How to do it

In the questions we have tagged for this topic (112 questions, 2021–2025), the types came up this often. 20 of the 112 questions mix types, so the counts add up to 136.

Question type	Questions
Identify the substance oxidised or reduced in an equation	33
Deduce an oxidation number (or its change)	20
Identify the oxidising agent and reducing agent	18
Explain from an equation how a substance is reduced or oxidised (oxygen loss or gain)	16
Explain oxidation or reduction using electron transfer or oxidation number	13
Define oxidation, reduction, redox, oxidising agent or reducing agent	11
Recognise a redox reaction	10
Redox tests: acidified potassium manganate(VII) and potassium iodide	8
Meaning of a Roman numeral in a name	7

1. Identify the substance oxidised or reduced in an equation (33 questions)

1. **Look only at the reactants** (left side). The answer is one of them, named as the whole substance.
2. **Core method (oxygen):** the reactant that **loses oxygen** is **reduced**; the reactant that **gains oxygen** is **oxidised**.
3. **Extended method (oxidation numbers):** when there is no oxygen moving, or the oxygen is hard to follow, work out the oxidation number of each element before and after. Up = oxidised; down = reduced.
4. Check the other option: if something is oxidised, something else must be reduced.

For example, $\mathrm{PbO} + \mathrm{C} \rightarrow \mathrm{Pb} + \mathrm{CO}$: lead(II) oxide loses oxygen, so it is reduced; carbon gains oxygen, so it is oxidised.

Variations you will meet:

- **"Which element is reduced?"** Give the element whose oxidation number falls. In $\mathrm{C} + 4\mathrm{HNO_3} \rightarrow \mathrm{CO_2} + 4\mathrm{NO_2} + 2\mathrm{H_2O}$, nitrogen goes from $+5$ (in $\mathrm{HNO_3}$) to $+4$ (in $\mathrm{NO_2}$), so nitrogen is reduced; carbon goes $0 \rightarrow +4$ and is oxidised; H and O do not change.
- **Carbon in two places**, $\mathrm{C} + \mathrm{CO_2} \rightarrow 2\mathrm{CO}$: carbon is oxidised ($0 \rightarrow +2$) **and** carbon dioxide is reduced ($+4 \rightarrow +2$).

- **An oxide that loses only some oxygen**, $\mathrm{PbO_2 + H_2 \rightarrow PbO + H_2O}$: lead goes $+4 \rightarrow +2$, so lead(IV) oxide is **reduced**, even though a lead oxide is still there at the end.
- **An oxide that gains more oxygen**, such as $\mathrm{2Cu_2O + O_2 \rightarrow 4CuO}$: copper(I) oxide gains oxygen and copper goes $+1 \rightarrow +2$, so copper(I) oxide is oxidised.
- **"Which equation shows the underlined substance being reduced?"**: check each equation separately; a reaction that is not redox (such as $\mathrm{MgO + 2HCl}$) reduces nothing.
- **Ethanol with acidified potassium manganate(VII)**: ethanol is **oxidised** (to ethanoic acid).

2. Deduce an oxidation number (or its change) (20 questions)

1. **Write the rule you need**: the total is 0 for a compound, or the charge for an ion.
2. **Add up the known atoms.** Multiply each oxidation number by the number of those atoms (for example $7 \times (-2) = -14$ for the oxygens in $\mathrm{P_2O_7^{4-}}$).
3. **Solve for the unknown**, dividing by the number of those atoms if there is more than one.
4. **Give the answer with its sign**: $+6$.

For example, phosphorus in $\mathrm{P_2O_7^{4-}}$: $2x + 7(-2) = -4$, so $2x = +10$ and $x = +5$ for **each** P. ($+10$ is the total for two atoms, a common kind of wrong option.)

Variations you will meet:

- **A compound with brackets**, such as magnesium nitrate, $\mathrm{Mg(NO_3)_2}$: Mg is $+2$, and there are 6 oxygens: $2 + 2x + 6(-2) = 0$, so $2x = 10$ and nitrogen is $+5$. (Or work on one $\mathrm{NO_3^-}$ ion: $x - 6 = -1$, $x = +5$.)
- **"State the sum of the oxidation numbers in the ion"**: it is the charge, for example -4 for $\mathrm{P_2O_7^{4-}}$.
- **The change for an element in an equation**, for example $\mathrm{Fe_2O_3 \rightarrow Fe}$: "from $+3$ to 0". Give both values, in order.
- **Uncombined elements** in an equation (C, $\mathrm{O_2}$, $\mathrm{N_2}$, Zn): always 0.
- **Core (Paper 1)**: iron in iron(III) oxide, $\mathrm{Fe_2O_3}$, is $+3$; read it from the Roman numeral.

3. Identify the oxidising agent and reducing agent (18 questions)

1. **Find what is reduced and what is oxidised** (oxidation numbers or electrons).
2. **The reactant that is reduced is the oxidising agent. The reactant that is oxidised is the reducing agent.**
3. **For a reason**, say what the agent does with electrons: the oxidising agent **gains electrons** (or its oxidation number decreases); the reducing agent **loses electrons**.

For example, $\mathrm{H_2S + Cl_2 \rightarrow S + 2HCl}$: S goes $-2 \rightarrow 0$ (oxidised) and Cl goes $0 \rightarrow -1$ (reduced). So $\mathrm{Cl_2}$ is the oxidising agent and $\mathrm{H_2S}$ the reducing agent.

Variations you will meet:

- **A multiple-choice statement** such as "Zn is the reducing agent and it reduces $\mathrm{Cu^{2+}}$". Check both halves: who is the agent, and what it does to the other substance.

- **"In which equations does the underlined species act as a reducing agent?"**: it must lose electrons (its oxidation number must rise) in that equation. In an acid–base reaction it is neither.
- **Blast furnace**: the gaseous reducing agent is **carbon monoxide**.
- **"J gains electrons"**: then J is reduced, so J is the **oxidising agent**.
- **Roles from colours**: if acidified manganate(VII) is decolourised by Fe^{2+}, manganate(VII) is the oxidising agent and Fe^{2+} the reducing agent.

4. Explain from an equation how a substance is reduced or oxidised (oxygen loss or gain) (16 questions)

1. **Name the substance** from the left of the equation.
2. **Say what happens to its oxygen**: "tin(IV) oxide **loses oxygen**" for reduced; "carbon **gains oxygen**" for oxidised.
3. Use the equation's substances. A definition alone ("reduction is loss of oxygen") does not answer "how does this equation show ...".

For example, "$\mathrm{SnO_2 + 2C \rightarrow Sn + 2CO}$: describe how the equation shows tin(IV) oxide is reduced." Answer: tin(IV) oxide loses oxygen (the oxygen is removed from the tin(IV) oxide and joins the carbon).

Variations you will meet:

- **Multiple choice**: "Why is this a reduction?" The answer is **loss of oxygen**, not the products weighing less or there being more products.
- **A compound other than a metal oxide**, such as $\mathrm{NaClO \rightarrow NaCl}$: NaClO loses oxygen, so it is reduced.

5. Explain oxidation or reduction using electron transfer or oxidation number (13 questions)

1. **Decide which definition the question asks for**: "in terms of electrons" or "in terms of oxidation number".
2. **Name the species** and give the change: "Fe^{2+} **loses an electron**" (oxidation), "chlorine **gains electrons**" (reduction), or "the oxidation number of nitrogen **increases** from -3 to $+2$".
3. **"Explain why this is a redox reaction"** needs **both** halves, one mark each: what loses electrons **and** what gains them.

For example, $\mathrm{Zn + 2Ag^+ \rightarrow Zn^{2+} + 2Ag}$ is redox because zinc atoms **lose** electrons (oxidised) and silver ions **gain** electrons (reduced).

Variations you will meet:

- **Ionic half-equations**: $\mathrm{Al^{3+} + 3e^- \rightarrow Al}$ has electrons on the **left**, gained: reduction. $\mathrm{2Cl^- \rightarrow Cl_2 + 2e^-}$ has electrons on the right, lost: oxidation.
- **A reversible reaction**: explain each direction separately with oxidation numbers. Whatever goes up in the forward direction goes back down in the reverse.

- **Multiple-choice traps**: "oxidised ions gain electrons" and "oxidation number decreases on oxidation" are both wrong.

6. Define oxidation, reduction, redox, oxidising agent or reducing agent (11 questions)

Learn these word for word in meaning:

- **Oxidation**: gain of oxygen (Core); loss of electrons; increase in oxidation number.
- **Reduction**: loss of oxygen (Core); gain of electrons; decrease in oxidation number.
- **Redox**: oxidation and reduction taking place at the same time.
- **Oxidising agent**: a substance that oxidises another substance **and is itself reduced** (2 marks, one for each half).
- **Reducing agent**: a substance that reduces another substance **and is itself oxidised**.

Use the definition the question asks for: "in terms of oxidation number" means increase or decrease, not electrons.

7. Recognise a redox reaction (10 questions)

1. **Look for oxygen gained or lost**, or an **element that becomes combined** (or uncombined): an element in the equation on one side only is a strong sign of redox, because its oxidation number changes from or to 0.
2. **Extended:** check oxidation numbers. Any change means redox.
3. **Not redox**: neutralisation, acid + carbonate, precipitation, thermal decomposition of carbonates, hydration of salts.

Redox: burning (complete or incomplete), rusting, metal + acid (gives hydrogen), metal + steam or water, metal + metal oxide, metal + metal ion, halogen + halide, metal oxide + carbon or hydrogen. The general name for reactions where electrons move from one species to another is **redox**.

8. Redox tests: acidified potassium manganate(VII) and potassium iodide (8 questions)

1. **Which reagent?** Manganate(VII) detects a **reducing agent**; iodide detects an **oxidising agent**.
2. **Colour changes, in order**: acidified manganate(VII) **purple** → **colourless**; potassium iodide **colourless** → **brown**.
3. **Product**: the iodide is oxidised to **iodine**; the manganate(VII) is reduced.
4. **Condition**: the manganate(VII) must be **acidified**.

Variations you will meet:

- **"Iodide ions reduce Fe^{3+} to Fe^{2+}. Name the other product."**: iodine.
- **Ethanol warmed with acidified manganate(VII)**: oxidation of the ethanol, purple to colourless.
- **No reaction**: the colour stays (purple/pink, or colourless for KI).

9. Meaning of a Roman numeral in a name (7 questions)

1. The numeral is **the oxidation number of the element it follows**, with a $+$ sign: iron(III) $\rightarrow +3$; manganate(VII) $\rightarrow$ manganese is $+7$.
2. **Name to formula**: balance the oxidation numbers to 0. Chromium(III) oxide: Cr $+3$, O -2, so $\mathrm{Cr_2O_3}$ ($2 \times 3 = 6 = 3 \times 2$).
3. **Formula to name**: find the metal's oxidation number and write it in Roman numerals: $\mathrm{Fe_2O_3} \rightarrow$ iron(III) oxide; MnO $\rightarrow$ manganese(II) oxide.
4. **"What is this number called?"**: the **oxidation number** (not valency or charge).

Worked examples

The bold codes show where marks are earned, as in Cambridge mark schemes. The number is how many marks.

- **M1** method mark: for a correct method, even if the numbers slip.
- **A1** accuracy mark: for a correct answer; it needs the M mark before it.
- **B1** mark for a correct result on its own, with no method needed.

Example 1

Lead(II) oxide is heated with hydrogen.

$$\mathrm{PbO + H_2 \rightarrow Pb + H_2O}$$

(a) State what the (II) in lead(II) oxide means. **[1]**

(b) Name the substance that is reduced. Describe how the equation shows this. **[2]**

(c) Name the substance that is oxidised. **[1]**

(d) Explain why this is a redox reaction. **[1]**

(a) The oxidation number of lead in the compound is $+2$. **B1** ("It means 2" or "the charge on the compound" does not score.)

(b) Lead(II) oxide. **B1** It loses oxygen. **B1**

(c) Hydrogen (it gains oxygen to form water). **B1**

(d) Oxidation and reduction happen at the same time. **B1**

Example 2

Extended. Oxygen has an oxidation number of -2 and sodium $+1$ in these compounds.

(a) Determine the oxidation number of sulfur in the sulfite ion, $\mathrm{SO_3^{2-}}$. Show your working. **[2]**

(b) Determine the oxidation number of chlorine in sodium chlorate, $\mathrm{NaClO_3}$. Show your working. **[2]**

(c) Sulfite ions are converted into sulfate ions, $\mathrm{SO_4^{2-}}$. Explain, in terms of oxidation number, whether the sulfur is oxidised or reduced. **[2]**

(a) $x + 3(-2) = -2$ **M1** (the ion's total is its charge; -6 for the oxygens), so $x = +4$. **A1**

(b) $+1 + x + 3(-2) = 0$ **M1**, so $x = +5$. **A1**

(c) In $\mathrm{SO_4^{2-}}$: $x + 4(-2) = -2$, so sulfur is $+6$. **B1** The oxidation number increases from $+4$ to $+6$, so sulfur is **oxidised**. **B1**

Example 3

Extended. Aluminium foil is added to aqueous copper(II) sulfate. A brown solid forms.

$$\mathrm{2Al(s) + 3Cu^{2+}(aq) \rightarrow 2Al^{3+}(aq) + 3Cu(s)}$$

(a) Give the change in oxidation number of aluminium and of copper. **[2]**

(b) Explain, in terms of electrons, which substance is oxidised. **[2]**

(c) Identify the oxidising agent. Give a reason. **[2]**

(d) Show that the electrons lost equal the electrons gained in the equation. **[1]**

(a) Aluminium: 0 to $+3$. **B1** Copper: $+2$ to 0. **B1**

(b) Aluminium **B1**, because each Al atom **loses** three electrons. **B1**

(c) Copper(II) ions, $\mathrm{Cu^{2+}}$. **B1** They gain electrons (they are reduced). **B1**

(d) 2 Al atoms lose $2 \times 3 = 6$ electrons; $3\ \mathrm{Cu^{2+}}$ ions gain $3 \times 2 = 6$ electrons. **B1**

Example 4

Extended. Acidified aqueous potassium manganate(VII) is added drop by drop to aqueous tin(II) chloride.

$$\mathrm{2MnO_4^-(aq) + 16H^+(aq) + 5Sn^{2+}(aq) \rightarrow 2Mn^{2+}(aq) + 5Sn^{4+}(aq) + 8H_2O(l)}$$

(a) Determine the oxidation number of manganese in $\mathrm{MnO_4^-}$. Show your working. **[2]**

(b) State the change in oxidation number of tin, and whether tin(II) ions are oxidised or reduced. **[2]**

(c) Identify the oxidising agent and the reducing agent. **[2]**

(d) State the colour change of the potassium manganate(VII). **[1]**

(e) Aqueous potassium iodide is added to a fresh sample of tin(II) chloride. The mixture stays colourless. Suggest what this shows about tin(II) ions. **[1]**

(a) $x + 4(-2) = -1$ **M1**, so $x = +7$. **A1**

(b) From $+2$ to $+4$ **B1**; the oxidation number increases, so tin(II) ions are **oxidised**. **B1**

(c) Oxidising agent: $\mathrm{MnO_4^-}$ (manganate(VII) ions; Mn goes from $+7$ to $+2$, so it is reduced). **B1** Reducing agent: $\mathrm{Sn^{2+}}$. **B1**

(d) From purple to colourless. **B1**

(e) No iodine (brown) formed, so the iodide was not oxidised: tin(II) ions are **not an oxidising agent** (they act as a reducing agent). **B1**

Common mistakes

- **Naming the product instead of the reactant.** "Silver is reduced" for $\mathrm{Ag_2O + C}$ is wrong: silver oxide is reduced. Likewise "oxygen is removed from iron" is not accurate, because iron is a product; say "iron(III) oxide loses oxygen".
- **Giving the definition instead of using the equation.** When asked how *this* equation shows reduction, name the substance and say it loses oxygen. A bare "reduction is loss of oxygen" is not enough.
- **Mixing up the substance reduced and the agent.** In multiple choice, examiners see the metal that is reduced chosen when the question asked for the substance that causes the reduction (the reducing agent).
- **Oxidation numbers without a sign.** "2" or "it is 2" is not an oxidation number; write $+2$. Every year some answers leave out the sign or give $+12$ (two chromiums) instead of $+6$ (each).
- **Saying the Roman numeral is the "charge of the compound", "the valency" or "the oxidation number of copper sulfate".** It is the oxidation number of the **element** it follows. Valency is not used in this syllabus.
- **Putting the numeral in the wrong place**: "potassium(VII) manganate" is wrong; it is potassium manganate(VII).
- **Half a definition of an agent.** "A substance that reduces another" earns one mark of two; add "and is itself oxidised". "Oxidises itself" is not the same as "is itself oxidised".
- **Explaining the oxidising agent by what it does** ("it oxidises the iodide") when the reason should be how: it **gains electrons**.
- **Explaining halogen displacement without naming both species.** Say which halide ion loses electrons and which halogen gains them, not just "electrons are transferred".
- **Saying acidified manganate(VII) turns colourless when there is no reaction.** With no reducing agent it stays purple (pink when dilute).

- **Wrong iodine colours.** Iodine is a **grey-black** solid; iodine in solution is **brown**. "Blue-black" is the starch test colour, not iodine itself.
- **Calling neutralisation or thermal decomposition redox.** Check whether any oxidation number changes.

How to get the marks

- **Name the whole reactant** (copper(II) oxide, not copper) when asked what is oxidised, reduced, or the agent. Use a name or a correct formula; a wrong formula loses the mark.
- **"Describe how the equation shows …"**: substance + "loses oxygen" or "gains oxygen".
- **"In terms of electrons"**: say which species **loses** or **gains** electrons. **"In terms of oxidation number"**: say it **increases** or **decreases**, with the values if you can.
- **"Show your working"** for an oxidation number: write the equation with the oxygen total (such as -14 or 7×-2) for the method mark, then the answer with its sign.
- **Definitions of agents are 2 marks**: what it does to the other substance, and what happens to itself.
- **Colour changes**: "from … to …", both colours, in order. For manganate(VII) also say **acidified** if asked for the condition or the reagent.
- **"Suggest"**: apply the rules to a reaction you have not seen; the question gives what you need.
- **Multiple choice with statements**: test every part of each statement; one wrong half makes it wrong.

Quick check

1. $\mathrm{Mg} + \mathrm{CuO} \rightarrow \mathrm{MgO} + \mathrm{Cu}$. Which substance is oxidised and which is reduced? Explain using oxygen.
2. What is the oxidation number of chromium in chromium(III) oxide? Write the formula of chromium(III) oxide.
3. **Extended.** Determine the oxidation number of nitrogen in the nitrate ion, $\mathrm{NO_3^-}$, and in the ammonium ion, $\mathrm{NH_4^+}$.
4. **Extended.** $2\mathrm{Fe^{3+}} + 2\mathrm{I^-} \rightarrow 2\mathrm{Fe^{2+}} + \mathrm{I_2}$. Identify the oxidising agent and the reducing agent, explaining in terms of electrons. What colour change would you see if $\mathrm{Fe^{3+}}$ were added to colourless aqueous potassium iodide?
5. **Extended.** Which of these is **not** a redox reaction? Explain using oxidation numbers. A $\mathrm{Zn} + \mathrm{H_2SO_4} \rightarrow \mathrm{ZnSO_4} + \mathrm{H_2}$ · B $\mathrm{NaOH} + \mathrm{HCl} \rightarrow \mathrm{NaCl} + \mathrm{H_2O}$ · C $2\mathrm{Na} + \mathrm{Cl_2} \rightarrow 2\mathrm{NaCl}$ · D $\mathrm{CH_4} + 2\mathrm{O_2} \rightarrow \mathrm{CO_2} + 2\mathrm{H_2O}$

Answers

1. Magnesium is oxidised: it gains oxygen (to form MgO). Copper(II) oxide is reduced: it loses oxygen (to form Cu).
2. $+3$. Cr is $+3$ and O is -2, so two Cr ($+6$) balance three O (-6): $\mathrm{Cr_2O_3}$.
3. $\mathrm{NO_3^-}$: $x + 3(-2) = -1$, so $x = +5$. $\mathrm{NH_4^+}$: $x + 4(+1) = +1$, so $x = -3$.
4. $\mathrm{Fe^{3+}}$ is the oxidising agent: each ion gains an electron (it is reduced, $+3 \rightarrow +2$). $\mathrm{I^-}$ is the reducing agent: iodide ions lose electrons (they are oxidised, $-1 \rightarrow 0$). The solution turns from colourless to brown, because iodine forms.
5. B. Na stays $+1$, O -2, H $+1$ and Cl -1; no oxidation number changes. (In A, Zn $0 \rightarrow +2$ and H $+1 \rightarrow 0$; in C, Na $0 \rightarrow +1$ and Cl $0 \rightarrow -1$; in D, C $-4 \rightarrow +4$ and O $0 \rightarrow -2$.)

Past questions to try

- **0620/42/M/J/25 Q4**: the sum of oxidation numbers in $\mathrm{Cr_2O_7^{2-}}$ and chromium's oxidation number, with working.
- **0620/41/M/J/25 Q4**: nitrogen's oxidation numbers in $\mathrm{NH_3}$ and NO, and oxidation defined by oxidation number.
- **0620/42/F/M/25 Q3**: chlorine and iodide ions, explained by electron transfer.
- **0620/32/M/J/24 Q7**: Core, describing how an equation shows a reduction.