Redox Map

AQA A Level Chemistry · 3.1.7 Oxidation, Reduction and Redox Equations

1 Oxidation states: the rules

3.1.7 iii–iv

- Uncombined element: 0 (Na, Cl_2, S_8)
- Monatomic ion: its charge (Mg^{2+} is +2)
- They add up to 0 in a compound, to the charge in an ion
- Always: F −1; Group 1 +1; Group 2 +2; Al +3
- H +1, but −1 in metal hydrides (NaH)
- O −2, but −1 in peroxides (H_2O_2), +2 in OF_2
- Cl −1, unless bonded to O or F

2 Roman numerals and formulae

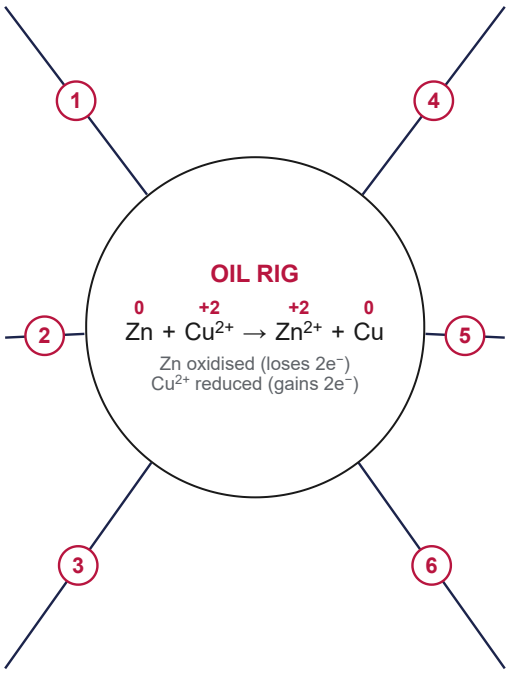
naming

- The numeral is the oxidation state of the element that can vary: $FeCl_3$ is iron(III) chloride
- Oxyanions: -ate + the central atom's oxidation state: SO_4^{2-} is sulfate(VI), NO_2^- nitrate(III)
- Name → formula: balance the oxidation states to zero: copper(I) oxide is Cu_2O
- No numeral when the oxidation state is fixed: sodium chloride

3 Oxidation and reduction

3.1.7 i–ii

- **Oxidation**: loss of electrons; oxidation state increases
- **Reduction**: gain of electrons; oxidation state decreases
- OIL RIG: Oxidation Is Loss, Reduction Is Gain
- Redox: both happen together; electrons lost = electrons gained
- Metals lose electrons to form positive ions; non-metals gain them to form negative ions



4 Oxidising and reducing agents

3.1.7 i–ii

- **Oxidising agent**: accepts electrons, so it is reduced (Cl_2, O_2, MnO_4^- in acid)
- **Reducing agent**: donates electrons, so it is oxidised (metals, H_2, C, CO)
- An agent is always a reactant: name the whole species (CO, not C)

5 Half-equations

3.1.7 v

- 1 balance the element that changes
- 2 balance O with H_2O
- 3 balance H with H^+
- 4 add e^- to balance the charge
- $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$
- Oxidation: e^- on the right. Reduction: e^- on the left

6 Combining half-equations

3.1.7 vi

- Make e^- lost = e^- gained, add, cancel the e^- (and any H^+ or H_2O on both sides)
- $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$
- $Fe^{2+} \rightarrow Fe^{3+} + e^-$ (× 5)
- $MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow Mn^{2+} + 4H_2O + 5Fe^{3+}$
- Check: atoms and charges balance (+17 on each side)

Common ions: charge and oxidation state of the central atom

oxidation states are written sign first; charges number first

Ion	Formula	Charge	Oxidation state	Systematic name
sulfate	SO_4^{2-}	2−	S +6	sulfate(VI)
sulfite	SO_3^{2-}	2−	S +4	sulfate(IV)
hydrogensulfate	HSO_4^-	1−	S +6	hydrogensulfate(VI)
thiosulfate	$S_2O_3^{2-}$	2−	S +2	thiosulfate
nitrate	NO_3^-	1−	N +5	nitrate(V)
nitrite	NO_2^-	1−	N +3	nitrate(III)
ammonium	NH_4^+	1+	N −3	ammonium
phosphate	PO_4^{3-}	3−	P +5	phosphate(V)

Ion	Formula	Charge	Oxidation state	Systematic name
carbonate	CO_3^{2-}	2−	C +4	carbonate
hydrogencarbonate	HCO_3^-	1−	C +4	hydrogencarbonate
hydroxide	OH^-	1−	O −2	hydroxide
hypochlorite	ClO^-	1−	Cl +1	chlorate(I)
chlorate	ClO_3^-	1−	Cl +5	chlorate(V)
permanganate	MnO_4^-	1−	Mn +7	manganate(VII)
dichromate	$Cr_2O_7^{2-}$	2−	Cr +6	dichromate(VI)
chromate	CrO_4^{2-}	2−	Cr +6	chromate(VI)

Worked examples

Working out an oxidation state

- Cr in $Cr_2O_7^{2-}$: $2x + 7(-2) = -2$, so $x = +6$
- S in H_2SO_4: $2(+1) + x + 4(-2) = 0$, so $x = +6$
- Fe in Fe_3O_4: $3x + 4(-2) = 0$, so $x = +8/3$ (a mixture of +2 and +3)

Is it redox?

- $Mg + 2HCl \rightarrow MgCl_2 + H_2$: yes (Mg 0 → +2, H +1 → 0)
- $NaOH + HCl \rightarrow NaCl + H_2O$: no (no oxidation state changes)
- $CaCO_3 \rightarrow CaO + CO_2$: no (Ca +2, C +4, O −2 throughout)

Write it right

- Charges: number first (2+). Oxidation states: sign first (+2)
- Spectator ions (Na^+, Cl^-, SO_4^{2-}) do not change and are left out of ionic equations
- Electrons never appear in an overall equation

Oxidation states assume every bond is ionic: the more electronegative atom takes the shared electrons.

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