

Oxidation numbers and balancing redox equations

Chemistry grades 11-12 (A Level · IB · Class 11-12) · Test answers (mark scheme)

Use these model answers and the marking notes to score yourself out of 20. Award method marks where a numerical slip occurs, but equations must balance for both atoms and charge to earn the full mark.

Level: Chemistry grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB R3.2

Question 1 Oxidation numbers of sulfur (3 marks)

- a. $2(+1) + x = 0$, so $S = -2$.
- b. $x + 2(-2) = 0$, so $S = +4$.
- c. $2(+1) + x + 4(-2) = 0$, so $S = +6$.

Marking: 1 mark for each correct value with sign.

Question 2 Ostwald process (2 marks)

- a. N: $-3 \rightarrow +2$; O: $0 \rightarrow -2$.
- b. **Nitrogen is oxidised** (oxidation number rises) and **oxygen is reduced**; the reducing agent is **NH₃**.

Marking: 1 mark for each part; (a) needs both elements correct.

Question 3 Chlorate half-equation (3 marks)

Cl: $+5 \rightarrow -1$, so 6 electrons are gained. Balance oxygen with H₂O and hydrogen with H⁺:

ClO₃⁻ + 6H⁺ + 6e⁻ → Cl⁻ + 3H₂O. Charge: $-1 + 6 - 6 = -1$ on both sides.

Marking: 1 mark for the correct species; 1 mark for H⁺ and H₂O balanced; 1 mark for electrons and charge balance.

Question 4 Chlorate and iron(II) (2 marks)

Multiply the iron half-equation by 6: **ClO₃⁻ + 6H⁺ + 6Fe²⁺ → Cl⁻ + 3H₂O + 6Fe³⁺**. Charge: $-1 + 6 + 12 = +17$ and $-1 + 18 = +17$.

Marking: 1 mark for multiplying by 6; 1 mark for the correct overall equation.

Question 5 Dichromate titration (4 marks)

$n(\text{Cr}_2\text{O}_7^{2-}) = 0.01940 \times 0.0100 = 1.94 \times 10^{-4} \text{ mol}$. Ratio 1 : 6, so $n(\text{Fe}^{2+}) = 6 \times 1.94 \times 10^{-4} = 1.164 \times 10^{-3} \text{ mol}$. $c = 1.164 \times 10^{-3} \div 0.0250 = \mathbf{0.0466 \text{ mol/dm}^3}$.

Marking: 1 mark for moles of dichromate; 1 mark for the ratio 1 : 6; 1 mark for moles of Fe^{2+} ; 1 mark for the concentration with unit.

Question 6 Hydrogen peroxide as two agents (2 marks)

Oxygen in H_2O_2 has oxidation number -1 , between -2 (as in water) and 0 (as in O_2). It can be reduced to -2 ($\text{H}_2\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow 2\text{H}_2\text{O}$), acting as an oxidising agent, or oxidised to 0 ($\text{H}_2\text{O}_2 \rightarrow \text{O}_2 + 2\text{H}^+ + 2\text{e}^-$), acting as a reducing agent.

Marking: 1 mark for -1 lying between -2 and 0 ; 1 mark for both reduction (oxidising agent) and oxidation (reducing agent).

Question 7 Copper(I) oxide in acid (2 marks)

Copper changes from $+1$ in Cu_2O to 0 in Cu (reduced) and to $+2$ in CuSO_4 (oxidised). The same element is both oxidised and reduced, so it is disproportionation.

Marking: 1 mark for the oxidation numbers 0 and $+2$; 1 mark for the statement that one element is both oxidised and reduced.

Question 8 Zinc and acid (2 marks)

Zn : $0 \rightarrow +2$ (oxidised). H : $+1 \rightarrow 0$ (reduced). Cl stays -1 . The reducing agent is **zinc**.

Marking: 1 mark for both oxidation number changes; 1 mark for zinc as reducing agent.