

Galvanic cells, electrode potentials and electrolysis

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. Method marks are awarded for the correct subtraction of potentials and for the correct mole ratio in the electrolysis calculations.

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

Question 1 Standard conditions (2 marks)

Any two of: temperature 298 K; ion concentration 1.00 mol/dm³; gas pressure 100 kPa. The potential of the standard hydrogen electrode is **0.00 V**.

Marking: 1 mark for two correct conditions; 1 mark for 0.00 V.

Question 2 Magnesium-silver cell (3 marks)

- a. $E^{\circ}_{\text{cell}} = 0.80 - (-2.37) = \mathbf{+3.17 \text{ V}}$.
- b. $\text{Mg} + 2\text{Ag}^+ \rightarrow \text{Mg}^{2+} + 2\text{Ag}$.
- c. The anode is **magnesium** (oxidation).

Marking: 1 mark for each part.

Question 3 Iron(III) and iodide (2 marks)

$E^{\circ}_{\text{cell}} = 0.77 - 0.54 = \mathbf{+0.23 \text{ V}}$. The value is positive, so the reaction is feasible: $2\text{Fe}^{3+} + 2\text{I}^- \rightarrow 2\text{Fe}^{2+} + \text{I}_2$.

Marking: 1 mark for +0.23 V; 1 mark for the conclusion.

Question 4 Refining copper (2 marks)

- a. At the **anode** (impure copper, right), $\text{Cu} \rightarrow \text{Cu}^{2+} + 2\text{e}^-$.
- b. At the **cathode** (pure copper, left), $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$.

Marking: 1 mark for each part.

Question 5 Nickel plating (3 marks)

$t = 2700 \text{ s}$; $Q = 1.50 \times 2700 = 4050 \text{ C}$. $n(\text{e}^-) = 4050 \div 96\,500 = 0.04197 \text{ mol}$. $\text{Ni}^{2+} + 2\text{e}^- \rightarrow \text{Ni}$, so $n(\text{Ni}) = 0.02098 \text{ mol}$. $m = 0.02098 \times 58.7 = \mathbf{1.23 \text{ g}}$.

Marking: 1 mark for the charge; 1 mark for moles of nickel; 1 mark for the mass.

Question 6 Hydrogen fuel cell (3 marks)

- a. Anode: $\text{H}_2 \rightarrow 2\text{H}^+ + 2\text{e}^-$. Cathode: $\text{O}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}$.
- b. A fuel cell can run continuously while fuel is supplied and does not need hours of recharging.

Marking: (a) 1 mark for each half-equation. (b) 1 mark for a valid advantage.

Question 7 The salt bridge (2 marks)

The reading would fall to **zero**. Without the salt bridge the circuit is incomplete, so ions cannot move to balance the charge, and the build-up of positive charge in the zinc half-cell stops the flow of electrons.

Marking: 1 mark for the reading falling to zero; 1 mark for the circuit being incomplete or charge building up.

Question 8 Brine electrolysis (3 marks)

Water ($E^\circ = -0.83 \text{ V}$) is reduced more easily than Na^+ ($E^\circ = -2.71 \text{ V}$), so the cathode reaction is $2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2 + 2\text{OH}^-$. At the anode the chloride ions are oxidised because the solution is concentrated: $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$, forming chlorine.

Marking: 1 mark for comparing E° values; 1 mark for hydrogen formed; 1 mark for chlorine with equation.