

Cells, cell potential and electrolysis

AP Chemistry · Test answers (mark scheme)

Model answers and mark allocations are shown below. Award error carried forward where a correct method follows an earlier slip, and withhold a mark when a final answer has no unit.

Level: AP Chemistry · **Curriculum:** AP Chem Unit 9

Question 1 Anode and cathode (2 marks)

- a. Oxidation (loss of electrons) occurs at the anode.
- b. The anode is **negative in a galvanic cell** and **positive in an electrolytic cell**.

Marking: 1 mark for oxidation; 1 mark for both signs correct.

Question 2 Magnesium and nickel cell (3 marks)

- a. Nickel has the higher E° : cathode, $\text{Ni}^{2+} + 2\text{e}^- \rightarrow \text{Ni}$.
- b. $E^\circ_{\text{cell}} = -0.25 - (-2.37) = \mathbf{+2.12\text{ V}}$.
- c. $\text{Mg} + \text{Ni}^{2+} \rightarrow \text{Mg}^{2+} + \text{Ni}$.

Marking: 1 mark per part; award part (b) for the correct sign and unit.

Question 3 Free energy and K for tin and copper (3 marks)

- a. $E^\circ_{\text{cell}} = 0.34 - (-0.14) = \mathbf{0.48\text{ V}}$.
- b. $n = 2$: $\Delta G^\circ = -2 \times 96\,485 \times 0.48 = -92\,626\text{ J/mol} = \mathbf{-92.6\text{ kJ/mol}}$.
- c. $\log K = 2 \times 0.48 / 0.0592 = 16.2$, so $\mathbf{K \approx 1.6 \times 10^{16}}$.

Marking: 1 mark per part; accept $\Delta G^\circ = -92.6$ or -93 kJ/mol .

Question 4 Voltage away from standard (2 marks)

- a. $Q = [\text{Zn}^{2+}]/[\text{Cu}^{2+}] = 0.010/1.0 = \mathbf{0.010}$.
- b. $E = 1.10 - (0.0592/2) \log(0.010) = 1.10 + 0.0592 = \mathbf{1.16\text{ V}}$.

Marking: 1 mark for Q; 1 mark for E (accept 1.159 V).

Question 5 Silver plating (3 marks)

- a. $Q = 0.500 \times 1800 = \mathbf{900\text{ C}}$.
- b. $n(\text{e}^-) = 900 / 96\,485 = \mathbf{9.33 \times 10^{-3}\text{ mol}}$.

- c. One electron per atom, so $m = 9.33 \times 10^{-3} \times 107.87 = \mathbf{1.01\text{ g}}$.

Marking: 1 mark per part; allow error carried forward.

Question 6 Brine electrolysis (2 marks)

Water is reduced at a less negative potential (-0.83 V) than Na^+ (-2.71 V), so $\mathbf{2H_2O + 2e^- \rightarrow H_2 + 2OH^-}$ occurs and sodium stays dissolved as Na^+ .

Marking: 1 mark for comparing the two potentials; 1 mark for the conclusion with the half-reaction.

Question 7 Reading a nickel-silver cell (3 marks)

- a. Nickel ($E^\circ -0.25\text{ V}$) is the anode: **electrons flow from X to Y**.
b. $\text{Ni} \rightarrow \text{Ni}^{2+} + 2\text{e}^-$ so electrode X **loses mass**; $\text{Ag}^+ + \text{e}^- \rightarrow \text{Ag}$ so electrode Y **gains mass**.
c. $Q = [\text{Ni}^{2+}]/[\text{Ag}^+]^2$ rises, so E falls below 1.05 V .

Marking: 1 mark per part.

Question 8 Free energy to potential (2 marks)

- a. $E^\circ = -\Delta G^\circ/(nF) = 193\,000 / (2 \times 96\,485) = \mathbf{1.00\text{ V}}$.
b. K is **greater than 1** because ΔG° is negative and E° is positive.

Marking: 1 mark per part.