Past-paper walk-through

Galvanic (Voltaic) and Electrolytic Cells ▪ 9.8

eXercise

Questions in this set

- 2025 Q6
- 2024 Q3
- 2023 Q1
- 2021 Q5
- 2018 Q6
- 2015 Q1
- 2014 Q3

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

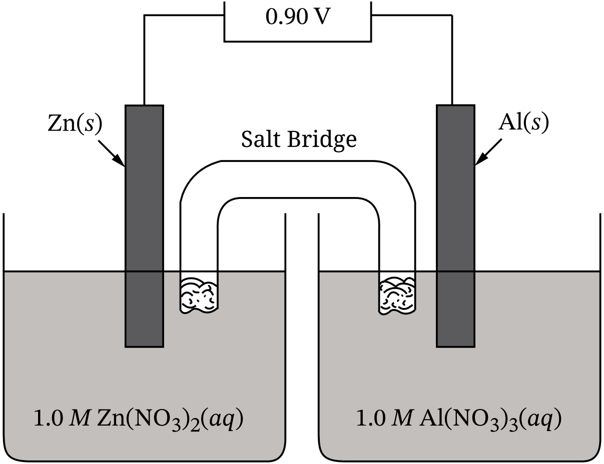
Question 6

2025 ▪ Q6

A scientist constructs a galvanic cell as shown in the diagram. As the cell operates, the Zn(s) electrode increases in mass and the Al(s) electrode decreases in mass. A data table with the standard reduction potentials for the substances follows the diagram. [Galvanic cell diagram: a voltmeter reading "0.90 V" connects two electrodes across the top. The left electrode is labeled "Zn(s)" (with an arrow pointing to it), immersed in a beaker of "1.0 M Zn($NO_3)_2(aq)$". The right electrode is labeled "Al(s)" (with an arrow pointing to it), immersed in a beaker of "1.0 M Al($NO_3)_3(aq)$". The two beakers are connected by a U-shaped "Salt Bridge" with cotton plugs at each end, shown dipping into each solution.]
| Half-Reaction | $E°$ (V) | |—|—| | $Zn^{2+}(aq) + 2\,e^- \rightarrow Zn(s)$ | -0.76 | | $Al^{3+}(aq) + 3\,e^- \rightarrow Al(s)$ | -1.66 |

(a) Write the half-reaction for the oxidation that occurs at the anode.

Question 6



Question 6

Reduction Half-Reaction	E° (V)
$Au^{3+}(aq) + 3\ e^- \rightarrow Au(s)$	$+1.50$
$Zn^{2+}(aq) + 2\ e^- \rightarrow Zn(s)$	-0.76
$Mn^{2+}(aq) + 2\ e^- \rightarrow Mn(s)$	-1.19
$Al^{3+}(aq) + 3\ e^- \rightarrow Al(s)$	-1.66
$Be^{2+}(aq) + 2\ e^- \rightarrow Be(s)$	-1.85

Question 6

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(b) Write the balanced net ionic equation for the overall reaction that occurs in the galvanic cell.

Question 6

2025 ▪ Q6

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(c) Initially, each electrode has a mass of 50.0 g. The cell is allowed to run for a period of time and is then stopped. Which electrode's mass changed the most? Justify your answer with a calculation.

Question 6

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Question 6

2025 ▪ Q6

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(d) The standard Zn/Al cell has a value of E°_{cell} equal to 0.90 V. The scientist needs a galvanic cell that produces a greater voltage. The scientist has access to the chemical systems in the table. If the scientist uses the Zn half-cell and one of the other options

Question 6

from the table, what is the MAXIMUM voltage that could be generated at standard conditions?

Solution 6

(a)

Mark scheme

- $\mathsf{Al}(s) \rightarrow \mathsf{Al}^{3+}(aq) + 3\,e^-$ (oxidation half-reaction at the anode; state symbols not required).

Solution 6

(b)

Mark scheme

- $2\,\mathrm{Al}(s) + 3\,\mathrm{Zn}^{2+}(aq) \rightarrow 2\,\mathrm{Al}^{3+}(aq) + 3\,\mathrm{Zn}(s)$ (balanced net ionic equation for the overall galvanic cell reaction; state symbols not required).

Solution 6

(c) Mark scheme

- Zn experiences the greater change in mass. Assuming the entire 50.0 g Al anode reacts: $50.0 \text{ g Al} \times \dfrac{1 \text{ mol Al}}{26.98 \text{ g Al}} \times \dfrac{3 \text{ mol Zn}}{2 \text{ mol Al}} \times \dfrac{65.38 \text{ g Zn}}{1 \text{ mol Zn}} = 182 \text{ g Zn}$ produced — far more than the 50.0 g of Al consumed. Equivalently, per mole of reaction: 3 mol Zn $\times$ 65.38 g/mol $=$ 196.1 g Zn deposited vs. 2 mol Al $\times$ 26.98 g/mol $=$ 53.96 g Al consumed, so the mass of Zn produced always exceeds the mass of Al consumed.

Solution 6

(d)

Mark scheme

- Pair the Zn half-cell (oxidation: $Zn(s) \rightarrow Zn^{2+}(aq) + 2\,e^-$, $E^\circ = +0.76$ V) with the Au^{3+}/Au half-reaction as the cathode ($E^\circ = +1.50$ V, the largest reduction potential available, greater than Mn or Al):
$E^\circ_{cell} = 1.50\text{ V} + 0.76\text{ V} = 2.26\text{ V}$. This is the maximum voltage obtainable from the table.

Question 3

2024 ▪ Q3

$$2\,Ag(s) + H_2S(g) \rightarrow Ag_2S(s) + H_2(g)$$

3. Sterling silver is an alloy that is commonly used to make jewelry and consists of 92.5

(a) What are the oxidation numbers of silver in $Ag(s)$ and $Ag_2S(s)$?

$Ag(s)$ $Ag_2S(s)$