Marks

- What is the electrochemical potential of the following cell at 25 °C? **3**

Fe | $FeSO_4$ (0.010 M) || ($FeSO_4$ (0.100 M) | Fe

As this is a concentration cell, E^o = 0 V. The cell notation corresponds to the 0.100 M solution being the cathode, where reduction occurs, and the 0.010 M solution being the anode, where oxidation occurs. The two half cells are:

Anode:	**Fe(s) → Fe^{2+}(aq, 0.010 M) + 2e^-**
Cathode:	**Fe^{2+}(aq, 0.100 M) + 2e^- → Fe(s)**
Overall:	**Fe^{2+}(aq, 0.100 M) → Fe^{2+}(aq, 0.010 M)**

The potential is given by the Nernst equation for this two electron reaction:

$$E = E° - \frac{RT}{nF} \ln Q$$

$$= (0 \text{ V}) - \frac{(8.314 \text{ J K}^{-1} \text{ mol}^{-1})(298 \text{ K})}{2 \times 96485 \text{ mol}^{-1}} \ln\frac{(0.010)}{(0.100)} = +0.0296 \text{ V}$$

Answer: **+0.0296 V**

- Calculate the mass of aluminium which can be produced with the same quantity of electricity that is used to produce 1.00 kg of copper metal. **2**

As the molar mass of Cu is 63.55 g mol^{-1}, 1.00 kg corresponds to:

number of moles = mass / molar mass
= 1.00 × 10^3 g / 63.55 g mol^{-1} = 15.7 mol.

Reduction of Cu^{2+} requires 2 mol of electrons. Hence, the number of electrons requires to produce 15.7 mol is:

number of moles of electrons = 2 × 15.7 mol = 31.5 mol

Reduction of a mole of Al^{3+} requires 3 mol of electrons. Hence, the number of moles of aluminium produced by 31.5 mol of electrons is:

number of moles of aluminium = 31.5 / 3 mol = 10.5 mol

As the molar mass of aluminium is 26.98 g mol^{-1}, this corresponds to:

mass = number of moles × molar mass = 10.5 mol × 26.98 g mol^{-1} = 283 g.

Answer: **283 g**

ANSWER CONTINUES ON THE NEXT PAGE

- Explain why Na(s) cannot be obtained by the electrolysis of aqueous NaCl solutions. **2**

From the table of standard reduction potentials:

$2H_2O + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$ $E° = –0.83$ V

$Na^+(aq) + e^- \rightarrow Na(s)$ $E° = –2.71$ V

Water has a much greater reduction potential than Na^+ and hence is preferentially reduced, even when the overpotential of water is considered.