Exercise walk-through

Cell Potential Under Nonstandard Conditions ▪ 9.10

eXercise

You must be able to

- use the **Nernst** idea: E falls as products build up
- predict how changing concentrations changes E_{cell}
- relate $E = 0$ to equilibrium

Method — Nonstandard conditions

The measured cell potential E differs from E° when concentrations are not 1 M. As the cell runs, reactants deplete and products build, so Q rises and E **falls**.

Method — Qualitative Nernst reasoning

- Increasing **reactant** concentration (or decreasing product) makes Q smaller $\rightarrow$ E **larger** (more favorable).
- Increasing **product** (or decreasing reactant) makes Q larger $\rightarrow$ E **smaller**.

Method — At equilibrium

When the cell reaches equilibrium, $Q = K$ and $E = 0$ — the battery is "dead" (no more driving force).

Method — A worked prediction

For $\mathrm{Zn} + \mathrm{Cu}^{2+} \rightarrow \mathrm{Zn}^{2+} + \mathrm{Cu}$: raising $[\mathrm{Cu}^{2+}]$ (a reactant) lowers Q, so E **increases** above E°.

Practice 2.1 ▪ 1 mark

As a battery runs, does E rise or fall?

Solution 2.1

Worked steps

Falls B1.

Practice 2.2 ▪ 1 mark

What is E when the cell reaches equilibrium?

Solution 2.2

Method: At equilibrium

Worked steps

Zero B1.

Practice 2.3 ▪ 1 mark

Increasing a reactant's concentration does what to E?

Solution 2.3

Method: Qualitative Nernst reasoning

Worked steps

Increases it B1.

Exam-style 3.1 ▪ 1 mark

When a galvanic cell reaches equilibrium, its cell potential is

A at a maximum

B zero

C negative

D equal to E°

Solution 3.1

Method: At equilibrium

A at a maximum

B zero ✓

C negative

D equal to E°

Worked steps

B — zero.

Exam-style 3.2 ▪ 2 marks

For $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$:
(a) State the effect on E of increasing $[Cu^{2+}]$.
(b) State the effect on E of increasing $[Zn^{2+}]$.

Solution 3.2

Method: A worked prediction

Worked steps

(a) Increasing $[Cu^{2+}]$ (a reactant) lowers Q, so E increases M1 A1. (b) Increasing $[Zn^{2+}]$ (a product) raises Q, so E decreases B1.

Exam-style 3.3 ▪ 2 marks

Explain why the voltage of a battery gradually drops to zero as it is used.

Solution 3.3

Worked steps

As the cell runs, reactants are used up and products accumulate, so Q rises toward K and E falls; at equilibrium $Q = K$ and $E = 0$ M1 A1.