

# 9.10 Cell Potential Under Nonstandard Conditions

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Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

Total: 9 marks

## Objective

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Build the skills to answer exam questions on **cell potential under nonstandard conditions**.

**You must be able to:**

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

## 1 Worked examples

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Study these first. Each one shows the method for a question type used later —follow the steps and you can do the Practice and Exam-style questions yourself.

### ■ Nonstandard conditions

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

### ■ 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**.

### ■ At equilibrium

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

### ■ A worked prediction

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

## 2 Practice

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Now apply the methods above.

2.1 As a battery runs, does  $E$  rise or fall? [1]

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2.2 What is  $E$  when the cell reaches equilibrium? [1]

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2.3 Increasing a reactant's concentration does what to  $E$ ? [1]

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### 3 Exam-style questions

3.1 When a galvanic cell reaches equilibrium, its cell potential is [1]

- **A** at a maximum
- **B** zero
- **C** negative
- **D** equal to  $E^\circ$

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3.2 For  $\text{Zn} + \text{Cu}^{2+} \rightarrow \text{Zn}^{2+} + \text{Cu}$ :

(a) State the effect on  $E$  of increasing  $[\text{Cu}^{2+}]$ . [2]

(b) State the effect on  $E$  of increasing  $[\text{Zn}^{2+}]$ . [1]

3.3 Explain why the voltage of a battery gradually drops to zero as it is used. [2]

### 4 Go further

You are now ready for the real exam questions on this subtopic:

- work through the **9.10 Cell Potential Under Nonstandard Conditions** lesson on the **Learn** page;
- read the **Cell Potential Under Nonstandard Conditions** section of the AP Chemistry handout on the **Know** page.

## Solutions

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**2.1** Falls.

**2.2** Zero.

**2.3** Increases it.

**3.1 B** —zero.

**3.2** (a) Increasing  $[\text{Cu}^{2+}]$  (a reactant) lowers  $Q$ , so  $E$  increases. (b) Increasing  $[\text{Zn}^{2+}]$  (a product) raises  $Q$ , so  $E$  decreases.

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