

9.9 Cell Potential and Free Energy

Name: _____ Class: _____ Date: _____

Total: 12 marks

KEY WORDS cell potential 电池电势 • anode 阳极 • cathode 阴极

Objective

Build the skills to answer exam questions on **cell potential and free energy**.

You must be able to:

- calculate $E_{\text{cell}}^{\circ} = E_{\text{cathode}}^{\circ} - E_{\text{anode}}^{\circ}$
- use $\Delta G^{\circ} = -nFE_{\text{cell}}^{\circ}$
- link a positive E_{cell}° to a favorable cell

1 Worked examples

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.

■ Standard cell potential

$$E_{\text{cell}}^{\circ} = E_{\text{cathode}}^{\circ} - E_{\text{anode}}^{\circ},$$

using standard reduction potentials. A **positive** E_{cell}° means a favorable (galvanic) cell.

■ A worked cell potential

Cu^{2+} ($E^{\circ} = +0.34$) as cathode, Zn^{2+} ($E^{\circ} = -0.76$) as anode:

$$E_{\text{cell}}^{\circ} = 0.34 - (-0.76) = +1.10 \text{ V}.$$

■ Linking to free energy

$$\Delta G^{\circ} = -nFE_{\text{cell}}^{\circ},$$

where n is moles of electrons transferred and $F = 96\,500 \text{ C/mol}$. A **positive** E° gives a **negative** ΔG° — favorable.

■ A worked ΔG

For $n = 2$, $E^{\circ} = 1.10 \text{ V}$: $\Delta G^{\circ} = -(2)(96\,500)(1.10) = -2.12 \times 10^5 \text{ J} = -212 \text{ kJ}$.

2 Practice

Now apply the methods above.

2.1 Write E_{cell}° in terms of the electrode potentials. [1]

2.2 For cathode $+0.80$ V and anode -0.44 V, find E_{cell}° . [2]

2.3 A cell has a positive E_{cell}° . Is it galvanic or electrolytic? [1]

3 Exam-style questions

3.1 A galvanic (favorable) cell has an E_{cell}° that is [1]

- **A** positive
 - **B** negative
 - **C** zero
 - **D** undefined
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3.2 A cell has $E_{\text{cathode}}^{\circ} = +0.34$ V and $E_{\text{anode}}^{\circ} = -0.76$ V, with $n = 2$.

(a) Find E_{cell}° . [2]

(b) Find ΔG° (use $F = 96\,500$ C/mol). [3]

3.3 Explain why a positive E_{cell}° corresponds to a negative ΔG° . [2]

Solutions

2.1 $E_{\text{cell}}^{\circ} = E_{\text{cathode}}^{\circ} - E_{\text{anode}}^{\circ}$.

2.2 $0.80 - (-0.44) = +1.24 \text{ V}$.

2.3 Galvanic.

3.1 A — positive.

3.2 (a) $E_{\text{cell}}^{\circ} = 0.34 - (-0.76) = +1.10 \text{ V}$. (b) $\Delta G^{\circ} = -(2)(96\,500)(1.10) = -2.12 \times 10^5 \text{ J} = -212 \text{ kJ}$.

3.3 $\Delta G^{\circ} = -nFE^{\circ}$; with n and F positive, a positive E° makes ΔG° negative — a favorable reaction.