AP CHEMISTRY • EXERCISE SHEET

9.9 Cell Potential and Free Energy

Name: _____ Class: _____ Date: _____ **Total: 12 marks**

Objective

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

You must be able to:

- calculate $E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$
- use $\Delta G^\circ = -nFE^\circ_{\text{cell}}$
- 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**

$$E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}},$$

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:

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

■ **Linking to free energy**

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

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

■ **A worked ΔG**

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

3.2 A cell has $E^\circ_{\text{cathode}} = +0.34$ V and $E^\circ_{\text{anode}} = -0.76$ 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]

4 Go further

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

- work through the **9.9 Cell Potential and Free Energy** lesson on the **Learn** page;
- read the **Cell Potential and Free Energy** section of the AP Chemistry handout on the **Know** page.

Solutions

2.1 $E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$.

2.2 $0.80 - (-0.44) = +1.24$ V.

2.3 Galvanic.

3.1 **A** —positive.

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

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