

Cells, cell potential and electrolysis

AP Chemistry · Lab

Name: _____ Date: _____ Class: _____

Can the voltage of a cell be predicted from a table of potentials? In this lab you build simple two-beaker cells, compare their voltages with data values and then test how dilution changes the voltage of a zinc-copper cell.

Level: AP Chemistry · **Curriculum:** AP Chem Unit 9

Aim

Rank four metals by the voltage they give against copper, then test how the voltage of a zinc-copper cell changes as the copper(II) ion concentration is diluted.

Equipment

- Strips of zinc, iron, magnesium, lead and copper, cleaned with sandpaper
- 0.50 mol/dm³ solutions of the metal sulfates or nitrates
- 0.50 mol/dm³ copper(II) sulfate and four dilutions (0.10, 0.010, 0.0010 mol/dm³)
- Small beakers, filter paper strips, potassium nitrate solution
- Digital multimeter with two leads and crocodile clips

Safety

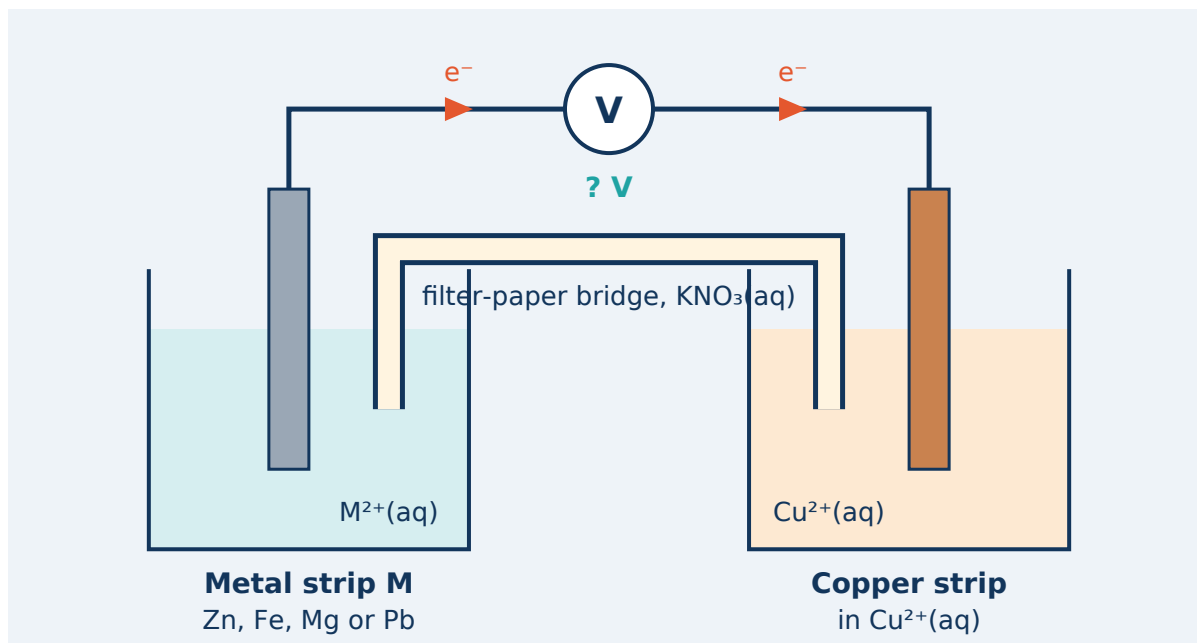
Safety

Wear safety goggles. Lead compounds are toxic: wear gloves and wash hands after use. Magnesium strip should not be near a flame. Collect all metal salt solutions for disposal; never pour them down the sink.

Method

1. Pour 50 cm³ of the metal solution into one beaker and 50 cm³ of copper sulfate into another.
2. Soak a filter-paper strip in potassium nitrate and fold it over both beaker rims as a bridge.
3. Clip the metal strip and the copper strip to the multimeter and record the steady reading, noting which lead is positive.
4. Repeat for each metal with a fresh bridge.
5. Keep zinc in 0.50 mol/dm³ zinc sulfate and swap the copper half-cell for each dilution;

record the voltage.



Results

Table 1: each metal against copper, solutions 0.50 mol/dm³, 22 °C.

Metal M	Measured voltage (V)	Positive terminal
Mg	2.61	Cu
Zn	1.07	Cu
Fe	0.75	Cu
Pb	0.45	Cu

Table 2: zinc-copper cell, zinc sulfate fixed at 0.50 mol/dm³, copper(II) sulfate diluted.

[Cu ²⁺] (mol/dm ³)	log [Cu ²⁺]	Voltage (V)
1.0	0	1.09
0.10	-1	1.06
0.010	-2	1.03
0.0010	-3	1.00

Analysis questions

Question 1 Identify the anodes

Use Table 1 to state which electrode is the anode in each pair and write the anode half-reaction for magnesium.

Question 2 Experimental potentials

Use $E^\circ(\text{Cu}^{2+}/\text{Cu}) = +0.34 \text{ V}$ to calculate E° for each M^{2+}/M couple from the measured voltages.

Question 3 Percentage difference

Compare the experimental $E^\circ(\text{Mg}^{2+}/\text{Mg})$ with the data value -2.37 V and calculate the percentage difference.

Question 4 Graph for the Nernst equation

Plot voltage (y) against $\log [\text{Cu}^{2+}]$ (x) from Table 2, draw the best line and find its gradient.

Question 5 Compare with theory

The Nernst equation predicts a gradient of $0.0592 / n$ for this cell. Calculate the predicted value and compare.

Question 6 Predict a new voltage

Use your graph to predict the voltage for $[\text{Cu}^{2+}] = 1.0 \times 10^{-4} \text{ mol/dm}^3$.

Question 7 Why readings differ

Name two reasons your measured voltages could differ from the data values, and say whether each raises or lowers the reading.

Question 8 Role of the bridge

Explain why the filter-paper bridge is needed and why a high-resistance multimeter is used.