B6 · Voltaic cells

Student notes - complete the underlined spaces | Notes 1/3

Explain how a voltaic cell works, label its parts, write its notation and half-reactions, predict observations and calculate E°cell.

Name: _____ Date: _____

1. Separate the halves

From direct contact to a cell

Zinc in copper(II) solution passes electrons _____ at the metal surface, and the energy appears as _____. To use that energy, we make the electrons travel along a path we choose.

In a voltaic cell (also called a galvanic cell), each metal sits in its own solution and a _____ joins them. A metal strip is an electrode. One electrode plus its solution is a half-cell, and the solution is the electrolyte, because its ions conduct charge.

Use the reduction table from B4. The higher value, Cu^{2+}/Cu _____, is the oxidizing agent. The lower value, Zn^{2+}/Zn _____, is the reducing agent.

The anode is where _____ happens and the cathode is where _____ happens. Here the zinc electrode is the _____ and the copper electrode is the _____. Memory aid: AN OX (anode, oxidation) and RED CAT (reduction, cathode).

On the diploma: label the electrodes by their job, because an option with the anode and cathode swapped is a classic wrong choice.

Watch: What makes electricity in a zinc–copper cell (Tyler DeWitt, “Introduction to Electrochemistry”, 4:33)

Watch: Set up the two half-cells (Tyler DeWitt, “Galvanic Cells (Voltaic Cells)”, 1:34)

Where charge moves

Electrons leave the anode, travel through the _____ and arrive at the cathode. Electrons do not travel through the _____. Moving ions carry the charge there.

Zinc releases electrons, so in a voltaic cell the anode is _____ and the cathode is _____.

On the diploma: describe electron flow as going from the anode through the wire to the cathode.

Watch: Why electrons flow through the wire (Tyler DeWitt, “Galvanic Cells (Voltaic Cells)”, 4:41)

Watch: Anode and cathode (Tyler DeWitt, “Galvanic Cells (Voltaic Cells)”, 10:04)

Watch: A way to remember anode and cathode (Tyler DeWitt, “Introduction to Electrochemistry”, 10:44)

Zn^{2+}/Zn −0.76 V; Cu^{2+}/Cu +0.34 V. Higher value is reduced.

Anode (oxidation): _____ Cathode (reduction): _____

Electron path: _____ → wire → _____

Notation: _____

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2. The salt bridge and cell notation

Keep the charge balanced

At the anode, $Zn \rightarrow Zn^{2+} + 2e^-$ makes the solution gain _____ charge. At the cathode, Cu^{2+} leaves the solution, which leaves extra _____ charge on anions, the negative ions such as sulfate.

A salt bridge, a tube of unreactive ions, or a porous barrier lets _____ move between the solutions. Anions move toward the _____ beaker and cations, the positive ions, move toward the _____ beaker.

Without a bridge, charge builds up and the electron flow _____. The bridge does not carry _____.

On the diploma: to explain why a cell stops, say charge builds up in each beaker. Match the ion type to the beaker with the opposite extra charge.

Watch: What the salt bridge does (Tyler DeWitt, “Galvanic Cells (Voltaic Cells)”, 16:48)

Watch: How ions move through the bridge (Tyler DeWitt, “Galvanic Cells (Voltaic Cells)”, 20:00)

Write the cell in one line

Notation: $Zn(s) \mid Zn^{2+}(aq) \parallel Cu^{2+}(aq) \mid Cu(s)$. The _____ is on the far left and the _____ is on the far right, because electrons start at the anode.

A single line | separates _____, such as an electrode and its solution. The double line || stands for the _____. Always write state symbols.

Read from the left: the half on the left of the double line is _____. Halves for this cell: $Zn \rightarrow Zn^{2+} +$ _____ and $Cu^{2+} + 2e^- \rightarrow$ _____.

On the diploma: a complete notation has the anode on the left, the double line in the middle and state symbols on every substance.

Watch: Cell notation (Tyler DeWitt, “Galvanic Cells (Voltaic Cells)”, 14:37)

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3. Predict, then calculate

Observations from the half-reactions

Every prediction comes from a half-reaction. Given Cu(s) | Cu^{2+}(aq) || Ag^{+}(aq) | Ag(s). The copper anode _____ mass as $Cu \rightarrow Cu^{2+} + 2e^{-}$. The copper solution is already blue, and more Cu^{2+} makes it _____ blue.

The silver cathode _____ mass because $2Ag^{+} + 2e^{-} \rightarrow$ _____. The Ag^{+} concentration _____.

The overall reaction is $Cu + 2Ag^{+} \rightarrow$ _____. Copper gives two electrons and each Ag^{+} takes one, so the silver half is multiplied by _____.

On the diploma: state the change in mass, concentration and colour from the half-reaction, and do not mix up the two electrodes.

Watch: What you would see in each half-cell (Tyler DeWitt, “Galvanic Cells (Voltaic Cells)”, 9:18)

Cell potential

$E°_{cell} = E°_{cathode} - E°$_____. This is the B4 rule, oxidizing agent minus reducing agent, with new names. Zn/Cu: $+0.34 - (-0.76) =$ _____. Cu/Ag: $+0.80 - (+0.34) =$ _____.

Do not multiply a table value when you multiply a half-reaction. A negative $E°_{cell}$ warns that the _____.

The notation always puts the _____ on the left, even when a drawing shows it on the right. Zn/Ag: $E°_{cell} = +0.80 - (-0.76) =$ _____.

On the diploma: keep the table signs, subtract cathode minus anode, and label electrodes from the table values, not from left and right.

Watch: Which metal pulls electrons harder (Tyler DeWitt, “Introduction to Electrochemistry”, 6:06)

B6 · Practice

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State symbols: (s) solid, (aq) dissolved in water, (l) liquid, (g) gas. Use the supplied reaction and conditions. B4 values name the Alberta Chemistry 30 Data Booklet table where used.

B6-P01 · Easy · Given Zn^{2+}/Zn −0.76 V and Cu^{2+}/Cu +0.34 V. Name the anode and the cathode, and write the half-reaction at each.

B6-P02 · Easy · Describe the path of the electrons and the path of the charge in a Zn / Cu cell with a salt bridge.

B6-P03 · Easy · Write the cell notation for a cell in which Mg(s) is oxidized and $Cu^{2+}(aq)$ is reduced, with a salt bridge.

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B6-P04 · Easy · Explain why a Zn / Cu cell with wires but no salt bridge or porous barrier stops after a moment.

B6-P05 · Medium · In a cell with a salt bridge containing $NaNO_3(aq)$, toward which beaker do the NO_3^- ions move in the cell $Cu(s) \mid Cu^{2+}(aq) \parallel Ag^+(aq) \mid Ag(s)$? Explain.

B6-P06 · Medium · Given Cu^{2+}/Cu +0.34 V and Ag^+/Ag +0.80 V. Write the half-reactions and the overall equation for the Cu / Ag cell.

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B6-P07 · Medium · Predict what happens to the mass of each electrode and to the colour of the copper solution while the Cu / Ag cell runs.

B6-P08 · Medium · Calculate E°cell for the Zn / Cu cell and for the Cu / Ag cell. Use Zn^{2+}/Zn −0.76 V, Cu^{2+}/Cu +0.34 V and Ag^{+}/Ag +0.80 V.

B6-P09 · Challenging · A student calculates E°cell = 0.34 − 0.80 = −0.46 V for the Cu / Ag cell. What was done wrong, and what is the correct value?

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B6-P10 · Challenging · Given Zn^{2+}/Zn −0.76 V and Ag^{+}/Ag +0.80 V. A drawing shows the silver half on the left. Name the anode, write the cell notation and calculate E°cell.

B6-P11 · Challenging · Predict the change in mass of each electrode in the Zn / Ag cell, $Zn(s) \mid Zn^{2+}(aq) \parallel Ag^{+}(aq) \mid Ag(s)$, and write the half-reaction that explains each change.

B6-P12 · Challenging · Explain why the double line in a cell notation is needed and what two half-cells it joins.