SI Chemistry - Full Discipline Demo

Electrochemical Cells and Cell Potentials

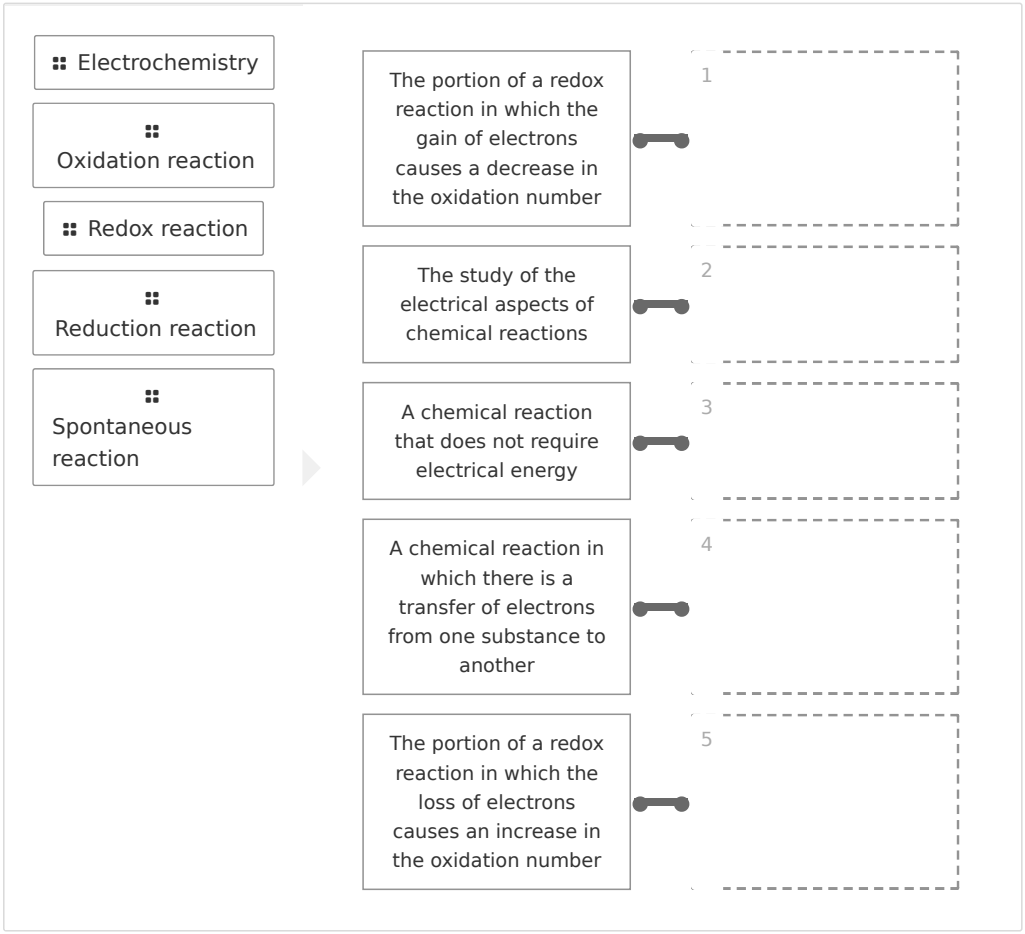
Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Chemistry - Full Discipline Demo
Course	SI Chemistry - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

Typesetting math: 100%

Match each term with the best description.



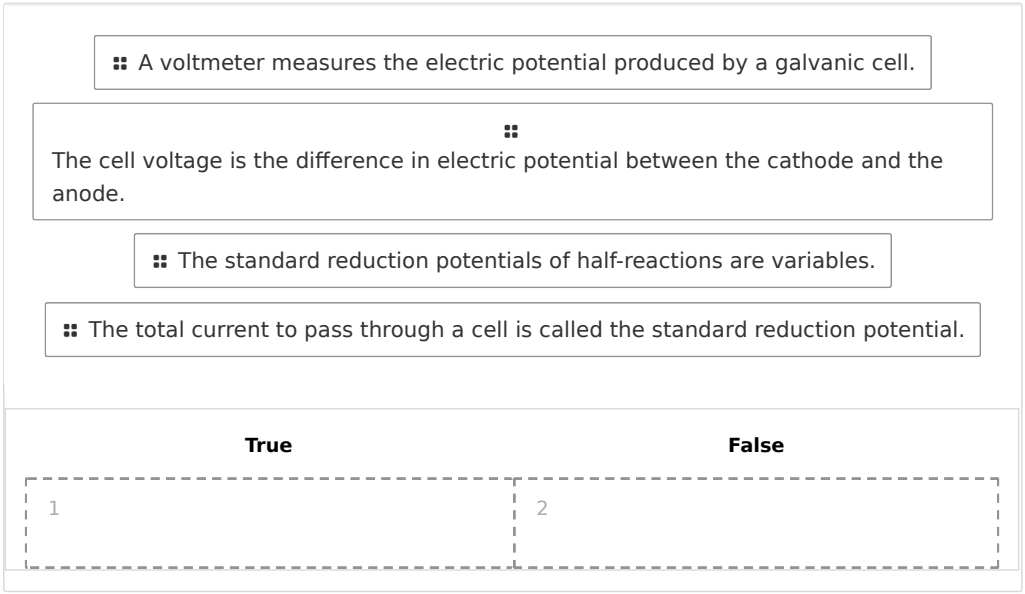
Correct answers:

1 Reduction reaction 2 Electrochemistry 3 Spontaneous reaction

4 Redox reaction 5 Oxidation reaction

Typesetting math: 100%

Classify each statement as true or false.



Correct answers:

1 A voltmeter measures the electric potential produced by a galvanic cell.

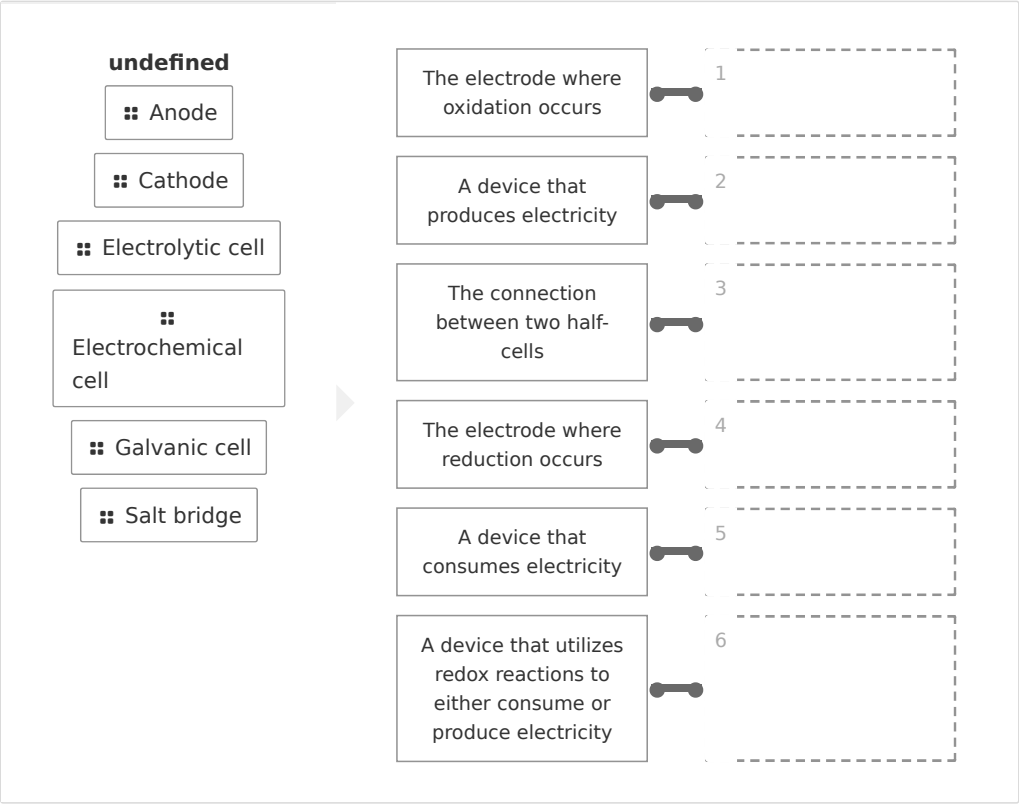
The cell voltage is the difference in electric potential between the cathode and the anode.

2

The total current to pass through a cell is called the standard reduction potential.

The standard reduction potentials of half-reactions are variables.

Match each term with the best description.



Correct answers:

1 Anode 2 Galvanic cell 3 Salt bridge 4 Cathode

5 Electrolytic cell 6 Electrochemical cell

Exploration

In a reduction half-reaction the gain of electrons causes a(n) _____ in the oxidation number.

- increase
- decrease ✔

Typesetting math: 100%

The electrode where oxidation occurs is called the _____, and the electrode where reduction occurs is called the _____.

- cathode; anode
- anode; cathode ✔
- oxidation; reduction

A salt bridge contains a(n) _____ electrolyte solution.

- inert ✔
- slippery
- reactive
- oxidizing

In a galvanic cell, the E_{cell} must be _____ for a spontaneous reaction to occur.

- negative
- positive ✔
- neutral

Exercise 1

What were the concentrations of the solutions (zinc solution, copper solution, and salt bridge)? Were the concentrations consistent with those of standard state conditions? Explain your answer.

The concentration of the zinc sulfate, the copper sulfate, and the potassium chloride are all 1M, which is the concentration consistent with those of the standard state conditions.

Was the electric potential found for your galvanic cell consistent with the standard cell potential of the reaction (as calculated in Data Table 3)? Hypothesize why it was or was not consistent.

The electric potential found for my galvanic cell was exactly what was expected. Both values were 1.10 Volts. I hypothesize that it was consistent because the redox reaction occurred under standard state conditions.
Or: The electric potential found for my galvanic cell was less than what was expected. My value was 1.07 Volts while the expected value was 1.10 Volts. I hypothesize that it was inconsistent because the redox reaction occurred under non-standard state conditions (the temperature was higher/lower than 25 °C).

Was there evidence of electron transfer from the anode to the cathode? Use your data in Data Table 2 to explain your answer.

Yes, there was evidence of electron transfer as the electric potential as recorded by the multimeter dropped from 1.10 volts to 1.06 volts over the 2.5 hour time period. Additionally, electron transfer was observed by the presence of a "black" deposit of Cu atoms on the surface of the copper strip.

For the following redox reaction in a galvanic cell, write the oxidation half-reaction and the reduction-half reaction, and calculate the standard cell potential of the reaction. Use Table 1 from the background as needed. Explain how you identified which substance was oxidized and which was reduced. Show all of your work.

Redox reaction: $\mathrm{Cu(s) + 2\,Fe^{3+}(aq) \rightarrow Cu^{2+}(aq) + 2\,Fe^{2+}(aq)}$

Table 1. Standard reduction potentials.

Half-Reaction	E°(Volts)
$F_2(g) + 2e^- \rightarrow 2F^-(aq)$	+2.87
$Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$	+1.36
$Br_2(l) + 2e^- \rightarrow 2Br^-(aq)$	+1.07
$Ag^+(aq) + e^- \rightarrow Ag(s)$	+0.80
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	+0.77
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	+0.34
$2H^+(aq) + 2e^- \rightarrow H_2(g)$	0.00
$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$	-0.44
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	-0.76
$Al^{3+}(aq) + 3e^- \rightarrow Al(s)$	-1.66
$Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$	-2.37
$Ca^{2+}(aq) + 2e^- \rightarrow Ca(s)$	-2.87
$K^+(aq) + e^- \rightarrow K(s)$	-2.93

The standard reduction potential for the copper was more negative than for the iron, thus the copper is the reducing agent and the iron the oxidizing agent.
Another view is: The copper increased in charge while the iron went down in charge, so the copper was oxidized and the iron was reduced.
Redox reaction: $Cu(s) + 2Fe^{3+}(aq) \rightarrow Cu^{2+}(aq) + 2Fe^{2+}(aq)$
Oxidation half-reaction: $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$ (E°=+0.34)
Reduction half-reaction: $2Fe^{3+}(aq) + 2e^- \rightarrow 2Fe^{2+}(aq)$ (E°=+0.77)
$E°_{cell} = E°_{red} + E°_{ox}$
$E°_{cell} = (0.77)+(-0.34)=+0.43$ Volts

Data Table 1: Spontaneous Reaction Observations

(SAMPLE ANSWER BELOW)

Metal in Solution:	Observations
Zinc in Copper (II) Sulfate Solution	The zinc is oxidized, as noted by the “rusting” appearance that immediately appears on the zinc. This is the copper metal from the solution, depositing itself onto the solid zinc. This reaction is the spontaneous reaction.
Copper in Zinc Sulfate Solution	The copper metal looks the same as it did before being inserted into the zinc sulfate solution. This reaction is not the spontaneous reaction.

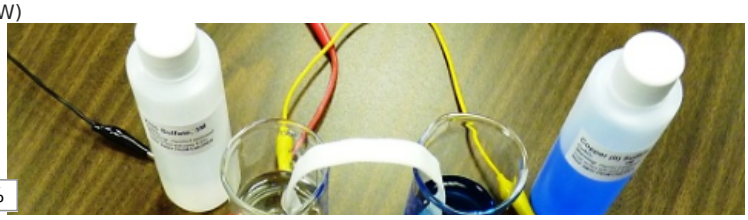
Data Table 2: Multimeter Readings
(SAMPLE ANSWER BELOW)

Time (minutes)	Multimeter Reading (Volts)
0	1.10
15	1.10
30	1.10
45	1.10
60	1.10
75	1.10
90	1.10
105	1.08
120	1.06
135	1.06
150	1.06

Data Table 3: Standard Cell Potential
(SAMPLE ANSWER BELOW)

	Equation	E°(Volts)
Oxidation Half-Reaction	$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^{-}$	$+0.76$
Reduction Half-Reaction	$Cu^{2+}(aq) + 2^{e-} \rightarrow Cu(s)$	$+0.34$
Redox Reaction	$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$	$+1.10$

Photo 1: Galvanic Cell Set-up
(SAMPLE ANSWER BELOW)



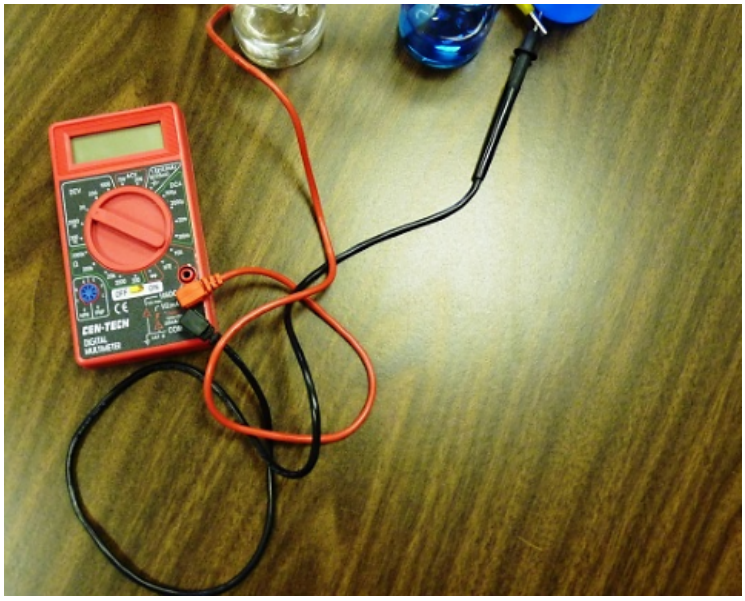
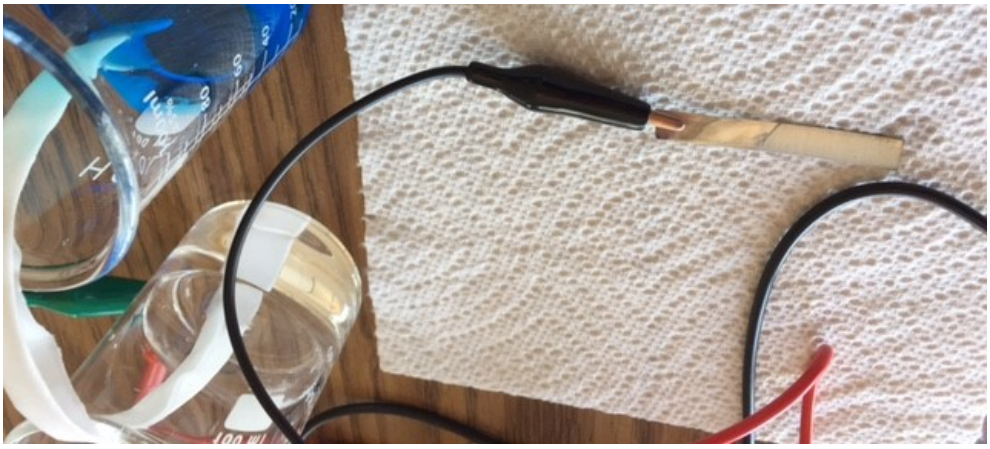


Photo 2: Metal Strips After Experiment

(SAMPLE ANSWER BELOW)



Competency Review

Electrochemistry is the study of chemical reactions that _____.

- generate electrical current
- use electrical current
- generate and use electrical current ✔

Typesetting math: 100%

A redox reaction occurs when electrons are transferred from one substance to another.

- True ✔
- False

In a(n) _____ half-reaction, the loss of electrons causes an increase in the oxidation number.

- oxidation ✔
- reduction

A galvanic cell produces electrical energy from a spontaneous redox reaction.

- True ✔
- False

A(n) _____ is the connection between two half-cells.

- cathode
- salt bridge ✔
- electrolytic cell
- anode

The voltage generated by a cell at standard state conditions is called the standard cell potential.

- True ✔
- False

Typesetting math: 100%

When constructing a galvanic cell using copper (II) and zinc sulfate solutions and strips, voltmeter, and filter paper soaked in potassium chloride, what material serves as the salt bridge?

- filter paper soaked in potassium chloride ✔
- zinc sulfate solution
- copper metal strip

If a galvanic cell is prepared correctly, what would the initial multimeter reading be?

- Negative
- Neutral
- Positive ✔

During an experiment using a galvanic cell for a chemical reaction, a change in voltage recorded over time indicates the transfer of electrons.

- True ✔
- False

During an experiment using a galvanic cell, the standard reduction potential for copper was found to be +0.34 volts and the standard reduction potential for zinc was found to be -0.76 volts. Which metal was functioning as the reducing agent in the galvanic cell?

- Copper
- Zinc ✔
- Both Copper and Zinc
- Neither Copper nor Zinc

Extension Questions

Use the standard reduction potentials in the table to create a galvanic cell with the highest possible standard cell voltage.

Half-Reaction	E°(Volts)
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a. Write the oxidation half-reaction.
b. Write the reduction half-reaction.
c. Calculate the standard cell voltage.
d. Write the overall cell reaction (redox reaction)

(SAMPLE ANSWER BELOW)

a. $2K(s) \Leftrightarrow 2K^+(aq) + 2e^-$
b. $F_2(g) + 2e^- \Leftrightarrow 2F^-(aq)$
c. 2.87 V – (-2.93 V) = 5.80 V
d. $2K(s) + F_2(g) \Leftrightarrow 2K^+(aq) + 2F^-(aq)$