

Electrochemical cells – Multiple Choice and Numerical Response – each valued at 2 pts.

1. Shelby compares a Voltaic cell to an electrolytic cell. The statement below that is **false** is _____
- a Both cells have oxidation happening at the anode
 - b In a voltaic cell, anions go the anode, while in the electrolytic cell, anions go to the cathode
 - c In an electrolytic cell electrical energy is converted to chemical energy, while in a voltaic cell, chemical energy is converted to electrical energy.
 - d A Voltaic cell is considered 'spontaneous' while an electrolytic cell is considered 'non-spontaneous'.
2. In a **spontaneous** cell, the electrons **leave** the _____ and travel **in** _____ to reach the _____.
- a Cathode Internal circuit Anode
 - b Anode Internal circuit Cathode
 - c Cathode External circuit Anode
 - d Anode External circuit Cathode
3. In an **electrolytic** cell, _____ travel to the anode and _____ travel to the cathode in the _____ circuit.
- a Anions Cations External
 - b Cations Anions External
 - c Anions Cations Internal
 - d Cations Anions internal

4. An electrolytic cell $\text{Zn(s)} \mid \text{Zn}^{2+}(\text{aq}) \parallel \text{Sn}^{2+}(\text{aq}) \mid \text{Sn(s)}$ has $1.0 \frac{\text{mol}}{\text{L}}$ solutions.

The net voltage of this cell is _____ V

- a -0.90
- b -0.62
- c +0.62
- d +0.90

5. Which cell is capable of recharging a 1.25 V battery?

- a $\text{Cu(s)} / \text{Cu}^{2+} // \text{Ag}^{+}(\text{aq}) / \text{Ag(s)}$
- b $\text{Al(s)} / \text{Al}^{3+}(\text{aq}) // \text{Sn}^{2+}(\text{aq}) / \text{Sn(s)}$
- c $\text{Co(s)} / \text{Co}^{2+}(\text{aq}) // \text{Pb}^{2+}(\text{aq}) / \text{Pb(s)}$
- d $\text{Fe(s)} / \text{Fe}^{2+}(\text{aq}) // \text{Ni}^{2+}(\text{aq}) / \text{Ni(s)}$

6. The E° value for the reaction that takes place when $\text{Cl}_2(\text{g})$ is added to $1.0 \frac{\text{mol}}{\text{L}}$ solution of $\text{NaI}(\text{aq})$ will be _____ V

- a -1.90
- b -0.82
- c +0.82
- d +1.90

7. Jon and Steve experimented with the following combination of reactants in a laboratory. Which combination will be **non-spontaneous** under standard conditions?
- a $\text{Ag}^+(\text{aq}) + \text{H}_2(\text{g})$
 - b $\text{Cr}(\text{s}) + \text{Sn}^{2+}(\text{aq})$
 - c $\text{Ba}(\text{s}) + \text{Fe}^{2+}(\text{aq})$
 - d $\text{Al}(\text{s}) + \text{Ca}^{2+}(\text{aq})$
8. For the reaction, $\text{Fe}(\text{s}) + \text{Sn}^{4+}(\text{aq}) \rightarrow \text{Sn}^{2+}(\text{aq}) + \text{Fe}^{2+}(\text{aq})$, a **true** statement is ____
- a $\text{Sn}^{4+}(\text{aq})$ caused $\text{Fe}(\text{s})$ to be reduced
 - b $\text{Fe}(\text{s})$ causes $\text{Sn}^{4+}(\text{aq})$ to be reduced
 - c $\text{Sn}^{2+}(\text{aq})$ is the oxidizing agent
 - d $\text{Fe}(\text{s})$ is the oxidizing agent
9. In a **Voltaic cell**, reduction occurs _____.
- a In the salt bridge
 - b At the cathode
 - c At the anode
 - d In the porous cup
10. In an **electrolytic cell**, oxidation occurs _____
- a In the salt bridge
 - b At the cathode
 - c At the anode
 - d In the porous cup

11. When a car battery produces electricity to start the engine, the battery is behaving as
- a An electrolytic cell
 - b A voltaic cell
 - c A system in which only oxidation is occurring
 - d A system in which only reduction is occurring
12. In a functioning **Voltaic cell**, electrons travel in the _____ circuit from the _____ to the _____.
- a Internal Anode Cathode
 - b Internal Cathode Anode
 - c External Anode Cathode
 - d external Cathode Anode
13. Which statement about electrochemical cells is **false**?
- a Anions go the anode, while cations go the cathode
 - b Oxidation occurs at the anode, reduction at the cathode
 - c Chemical energy will always be converted to electrical energy.
 - d E° for the cell will be negative.

14. Jason and Kyle read the line notation for a **Voltaic cell**.



They decide that the Zn(s) acts as the _____ and _____, while Cu(s) acts as the _____

- a Anode Oxidizing agent Cathode
- b Anode Reducing agent Cathode
- c Cathode Oxidizing agent Anode
- d Cathode Reducing agent Anode

15. Consider the seven statements given below.

- 1 Oxidation occurs at the anode where electrons are lost.
- 2 Oxidation occurs at the cathode where electrons are gained.
- 3 Reduction occurs at the anode where electrons are lost.
- 4 The oxidizing agent undergoes reduction at the cathode.
- 5 The reducing agent undergoes oxidation at the anode.
- 6 The oxidation number of the reducing agent goes up as oxidation occurs.
- 7 The oxidation number of the oxidizing agent goes down as reduction occurs.

Choose the **FALSE** statement(s) from the statements listed above.

- a 1,4,5,6,7
- b 2,3,6
- c 2,3
- d 6,7

16. Consider the seven statements given below.

- 1 Oxidation occurs at the anode where electrons are lost.
- 2 Oxidation occurs at the cathode where electrons are gained.
- 3 Reduction occurs at the anode where electrons are lost.
- 4 The oxidizing agent undergoes reduction at the cathode.
- 5 The reducing agent undergoes oxidation at the anode.
- 6 The oxidation number of the reducing agent goes up as oxidation occurs.
- 7 The oxidation number of the oxidizing agent goes down as reduction occurs.

The total number of **TRUE** statement(s) given above is _____

- a 2
- b 4
- c 5
- d 6

17. If the oxidizing agent is **higher** on the reduction table than the reducing agent, then the cell is called a _____ cell and the net voltage will be _____

- a Voltaic Positive
- b Electrolytic Negative
- c Voltaic Negative
- d Electrolytic Positive

18. Samantha and Ashleigh study the line notation for an electrochemical cell.



They predict the reaction at the **cathode** of this cell to be _____

- a $\text{Fe}^{3+}(\text{aq}) + \text{e}^- \rightarrow \text{Fe}^{2+}(\text{aq})$
 - b $\text{Cr}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cr(s)}$
 - c $\text{Cr}^{2+}(\text{aq}) \rightarrow \text{Cr}^{3+}(\text{aq}) + \text{e}^-$
 - d $\text{Fe}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Fe(s)}$
19. Colbe and Mike write a series of statements about electrochemical cells. Some of their statements are true for both Voltaic and Electrolytic cells some are true only for one type of cell, and some are not true for either type of cell.

Consider the statements given below.

Number Statement

- 1 Reduction happens at the cathode.
- 2 Electrons travel in the external circuit of the cell.
- 3 Anions travel to the cathode and cations travel to the anode.
- 4 Electrical energy is converted to chemical energy.
- 5 The reducing agent is higher on the reduction table than the oxidizing agent.
- 6 Electrons are gained at the anode.
- 7 Metals are plated at the anode.
- 8 The cathode has a positive charge.

The **TOTAL** number of statements that is /are true **ONLY** for electrolytic cells is/are _____

- a 1
- b 2
- c 3
- d 4

20. Colbe and Mike write a series of statements about electrochemical cells. Some of their statements are true for both Voltaic and Electrolytic cells some are true only for one type of cell, and some are not true for either type of cell.

Consider the statements given below.

Number Statement

- 1 Reduction happens at the cathode.
- 2 Electrons travel in the external circuit of the cell.
- 3 Anions travel to the cathode and cations travel to the anode.
- 4 Electrical energy is converted to chemical energy.
- 5 The reducing agent is higher on the reduction table than the oxidizing agent.
- 6 Electrons are gained at the anode.
- 7 Metals are plated at the anode.
- 8 The cathode has a positive charge.

The number of statements that are **NOT true for any cell** is/are _____

- a 1
- b 2
- c 3
- d 4

21. Colbe and Mike write a series of statements about electrochemical cells. Some of their statements are true for both Voltaic and Electrolytic cells some are true only for one type of cell, and some are not true for either type of cell.

Consider the statements given below.

Number Statement

- 1 Reduction happens at the cathode.
- 2 Electrons travel in the external circuit of the cell.
- 3 Anions travel to the cathode and cations travel to the anode.
- 4 Electrical energy is converted to chemical energy.
- 5 The reducing agent is higher on the reduction table than the oxidizing agent.
- 6 Electrons are gained at the anode.
- 7 Metals are plated at the anode.
- 8 The cathode has a positive charge.

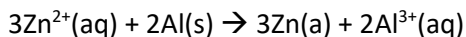
The **TOTAL** number of statements that is /are **true for both types of cells** is/are _____

- a 1
- b 2
- c 3
- d 4

22. During the electroplating of copper spoons, copper is deposited by

a	oxidizing copper ions at the cathode
b	reducing copper ions at the cathode
c	oxidizing copper ions at the anode
d	reducing copper ions at the anode

23. Use this information to answer the question that follows.



This equation represents the reaction in an electrochemical cell.

The half-cell reaction that occurs at the anode is _____

a	$\text{Zn}(\text{s}) \rightarrow 2\text{e}^- + \text{Zn}^{2+}(\text{aq})$
b	$\text{Zn}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Zn}(\text{s})$
c	$\text{Al}(\text{s}) \rightarrow 3\text{e}^- + \text{Al}^{3+}(\text{aq})$
d	$\text{Al}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Al}(\text{s})$

24. In an electrochemical cell, the cathode is the electrode at which electrons _____ the half cell and _____ takes place.

a	Leave	Oxidation
b	Leave	Reduction
c	Enter	Oxidation
d	Enter	Reduction

25. If the reference point for electrode potentials is changed so that the reduction of
- $\text{Ni}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Ni}(\text{s})$
- represents
- $E^\circ = 0.00 \text{ V}$
- , then the electrode potential for the reduction of
- $\text{Br}_2(\text{l}) + 2\text{e}^- \rightarrow 2\text{Br}^-(\text{aq})$
- will

be _____ V

a	+0.26
b	+0.81
c	+1.07
d	+1.33

26. If the reduction of iodine had been selected as the standard half- reaction, then the
- E°
- for the reduction of
- $\text{PbSO}_4(\text{s})$
- would be _____ V

a	-0.90
b	+0.90
c	-0.18
d	+0.18

27. Scientists Tom and Janel rewrite the reduction table in the data booklet.

They choose the half reaction $\text{I}_2(\text{s}) + 2\text{e}^- \rightarrow 2\text{I}^-(\text{aq})$ as the new reference point.

Based on this new reference point, choose the **true** statement below is ____.

a	$\text{Pb}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Pb}(\text{s})$	$E^\circ = -0.67 \text{ V}$
b	$2\text{F}^-(\text{aq}) \rightarrow \text{F}_2(\text{g}) + 2\text{e}^-$	$E^\circ = +2.33 \text{ V}$
c	$\text{Fe}^{2+}(\text{aq}) \rightarrow \text{Fe}^{3+}(\text{aq}) + \text{e}^-$	$E^\circ = +1.31 \text{ V}$
d	$\text{Cr}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cr}(\text{s})$	$E^\circ = -0.37 \text{ V}$

28. Eli and Grayson choose a new reference point for the reduction table.

They decide that $\text{PbSO}_4(\text{s}) + 2\text{e}^- \rightarrow \text{Pb}(\text{s}) + \text{SO}_4^{2-}(\text{aq})$ will have an electrical potential of 0.0V

Using this new reference point they calculate the expected electrical potential for a series of reactions.

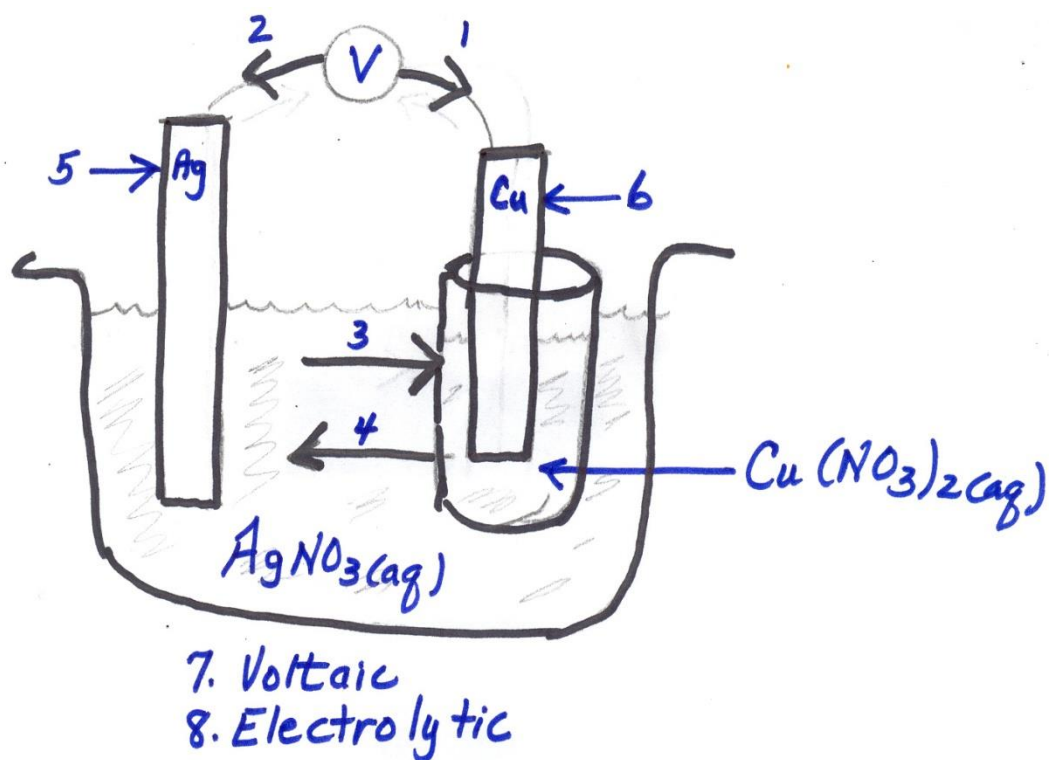
	Reaction	Voltage
1	$\text{Ni}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Ni}(\text{s})$	0.20 V
2	$\text{I}_2(\text{s}) + \text{Cu}(\text{s}) \rightarrow 2\text{I}^-(\text{aq}) + \text{Cu}^{2+}(\text{aq})$	0.20 V
3	$\text{NO}(\text{g}) + 2\text{OH}^- \rightarrow \text{NO}_2^-(\text{aq}) + \text{H}_2\text{O}(\text{l}) + \text{e}^-$	0.20 V
4	$3\text{N}_2\text{O}(\text{g}) + 6\text{H}_2\text{O}(\text{l}) + 4\text{Au}^{3+}(\text{aq}) \rightarrow 6\text{HNO}_3(\text{aq}) + 12\text{H}^+(\text{aq}) + 4\text{Au}(\text{s})$	0.20 V
5	$2\text{Na}^+(\text{aq}) + \text{Ba}(\text{s}) \rightarrow \text{Ba}^{2+} + 2\text{Na}(\text{s})$	0.20 V

Which statements above are **FALSE**?

a	1,2,3
b	2,4,5
c	3,5
d	1,3

29. Numerical response question:

Consider the electrochemical cell illustrated below



Using the numbers in the diagram, identify

1. Type of cell _____
2. Anode _____
3. Direction of flow of electrons _____
4. Direction of flow of cations _____

30. Numerical response question:

Students are given the following list of chemical reagents

1. Strip of cadmium metal
2. Strip of nickel metal
3. Carbon rod(s)
4. Strip of zinc metal
5. Strip of copper metal
6. Nickel (II) sulfate solution
7. Cadmium sulfate solution
8. Potassium sulfate solution
9. Zinc sulfate solution

If asked to make the strongest possible **Voltaic cell**, the student should choose

Anode, Cathode, anion, cation

_____, _____, _____, _____

31. Numerical response question:

Consider the numbered statements about electrochemical cells given below.

- 1 Oxidation occurs at the cathode
- 2 The reducing agent reacts at the anode
- 3 Anions move through the external wire to the anode
- 4 Cations move through the electrolyte to the anode
- 5 Electrons move through the external wire to the cathode
- 6 Chemical energy is converted to thermal energy
- 7 Chemical energy is converted to electrical energy
- 8 Cations move through the internal circuit to the cathode.

The statements numbered above that apply to **both electrolytic cells and voltaic cells** are _____, _____, _____, and _____.

32. Numerical response question:

Consider the numbered statements about electrochemical cells given below.

1. the reaction is spontaneous
2. The cathode is the positive electrode
3. The anode is the positive electrode
4. Electrons travel from the anode to the cathode
5. Electrons travel from the cathode to the anode
6. Anions travel to the anode
7. Anions travel to the cathode
8. Cations travel to the cathode
9. Cations travel to the anode

List the statements numbered above that apply to both electrolytic cells and voltaic cells. Put the numbers in **ascending order**.

33. In the Hall-Herlout process, molten aluminium oxide ($\text{Al}_2\text{O}_3(\text{l})$) is used to produce aluminium metal ($\text{Al}(\text{s})$).

A current of _____ A must run for 24.0 h to produce 4.00 kg of aluminium at the cathode

a	497
b	166
c	2.98×10^3
d	1.78×10^6

34. Mattie and Stephanie weigh the anode of a cell and find the initial mass to be 8.53 g. They then run a current of 2.50 A for 2.00 h. If the final mass of the anode is 3.32 g, then the anode is made of _____.

a	Zinc
b	Copper
c	Magnesium
d	Iron

35. Nic and Jordan weigh the anode of a cell and find the initial mass to be 20.8 g. They run a current of 4.00 A for a time of 2.50 h. When they disconnect and weigh again, the final mass of the anode is 9.90 g. Based on these observations; the boys conclude that the anode is made of _____.

a	Tin
b	Nickel
c	Zinc
d	Cobalt

36. The amount of time that it will take to plate out all the copper from 25 mL of $0.10 \frac{\text{mol}}{\text{L}}$ copper (II) nitrate will be _____ min. Assume the current used is 1.5 A.

a	5.4
b	2.7
c	11
d	3.2×10^2

37. The time to produce 5.40 g of $\text{Al}(\text{s})$ from molten bauxite ($\text{Al}_2\text{O}_3(\text{l})$) using a current of 5.00 A will be _____ h

a	1.07
b	193
c	3.22
d	9.66

38. Silver plating of ornaments or utensils is done by electrolysis of a soluble silver compound. The object to be plated is placed at the cathode. If 10.8 g of silver are to be deposited, how long will it take to plate the object using a current of 0.500 A?

a	2.68 h
b	5.37 h
c	3.22×10^2 h
d	1.93×10^4 h

39. The time required to plate out 10.0 g of chromium metal from a $0.10 \frac{\text{mol}}{\text{L}}$ solution of chromium(II) nitrate in an electrolytic cell is dependent mainly upon _____

a	Surface area of the anode in the cell
b	initial mass of the cathode in the cell
c	amount of current supplied to the cell
d	charge of the nitrate ions in the solution

40. An electrolytic cell contains $2.00 \frac{\text{mol}}{\text{L}}$ $\text{NiCl}_2(\text{aq})$ and operates at 0.500 A. To plate out 5.87 g of Ni(s), the cell will function for _____ s

a	1.93×10^4
b	3.86×10^4
c	7.72×10^4
d	1.52×10^5

41. What mass of aluminum is deposited during the electrolysis of molten aluminum bromide if 30.0 A flow through the cell for 4.85 h?

a	146 g
b	48.8 g
c	1.46 g
d	0.0351 g

42. Ian and Crystal set up an electrochemical cell where 1.5 g of Zn(s) is removed from the anode. If the cell has run for a total of 1.0 hours, then the cell will need a minimum current of ____ A

a	1.2
b	2.4
c	0.60
d	12

43. Anne and Carly set up an electrochemical cell where 0.250 mol of $\text{Cu}^{2+}(\text{aq})$ is formed from Cu(s). If the cell has run for 45.0 minutes, the cell will need a minimum current of ____ A.

a	8.94
b	3.36
c	17.9
d	0.298

44. Bill and Wayne are asked to collect evidence to support the theoretical value of Faraday's constant. They collect the following data using aluminium at the anode.

Initial mass of anode	Final mass of anode	Amperage of cell	Time the cell operates
15.0 g	10.9 g	6.80 A	105 min

Based on this information, the experimental value of Faraday's constant is _____ $\frac{\text{C}}{\text{mol}}$

a	1.57×10^4
b	9.40×10^4
c	5.64×10^6
d	3.13×10^4

45. Theresa and Wendy are asked to collect evidence to support the theoretical value of Faraday's constant. They collect the following data using zinc at the anode.

Initial mass of anode	Final mass of anode	Amperage of cell	Time the cell operates
31.5	13.5 g	9.00 A	1.50 h

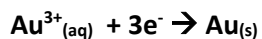
Based on this information, the experimental value of Faraday's constant is _____ $\frac{C}{mol}$

a	4.42×10^4
b	2.40×10^4
c	1.77×10^5
d	8.83×10^4

Numerical response question 46 : Use the boxes provided.

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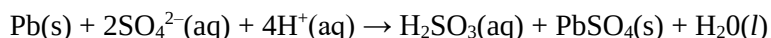
A mass of 0.175 g of gold is plated on a ring in 10.0 min according to the half reaction given below



The current required to do this is a.bc x 10^{-d} amps.

(Each valued at 3 pts) To receive full marks you must submit workings for all questions below.

1. Use the *Alberta Chemistry Data Booklet* to calculate the cell potential of the following reaction.



2. A technician wants to electroplate 10.0 g of gold onto a ring by immersing it in a solution of $\text{AuCl}_3(\text{aq})$ and using a power source that supplies 4.00 A of current. For what length of time, in minutes, should the cell be allowed to operate?
3. What is the volume of 0.0250 mol/L $\text{Ag}^+(\text{aq})$ necessary to react exactly with 2.18 g of Zn(s) ?
4. Silver plating of ornaments or utensils is done by electrolysis of a soluble silver compound. The object to be plated is placed at one of the electrodes. If 10.8 g of silver is to be deposited, how long, in minutes, will it take to plate the object using a current of 0.500 A?
5. How long, in minutes, must a cell run to produce 1.00 g of Na(l) in a molten NaCl(l) electrolytic cell that is operating at 10.0 A?
6. A voltaic cell is made of $\text{Fe}^{2+}(\text{aq})/\text{Fe}$ and $\text{Mg}/\text{Mg}^{2+}(\text{aq})$. If the iron electrode undergoes a mass change of 0.50 g, what will be the change in mass of the magnesium electrode?
7. An unknown metal chloride with the formula MCl_3 undergoes electrolysis using a current of 6.50 A for 1000 s and deposits 1.56 g. What is the molar mass of the metal?
8. A salt of an aqueous solution of copper is electrolyzed by a current of 3.50 A running for 50.0 min. If 3.457 g Cu is produced at the cathode, what is the charge of the copper ions in solution?
9. What is the cell potential of an electrolytic cell made of $\text{Al}^{3+}(\text{aq})$ and Cd(s) ?