

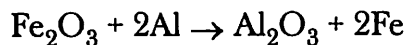
- What is the oxidation state of nitrogen in the compound NH_4Br ?
 - 1
 - +2
 - 3
 - +4
- What is the oxidation number of sulfur in $\text{Na}_2\text{S}_2\text{O}_3$?
 - 1
 - +2
 - +6
 - +4
- Given the balanced equation representing a reaction:

$$2\text{KClO}_3(\text{s}) \rightarrow 2\text{KCl}(\text{s}) + 3\text{O}_2(\text{g})$$

The oxidation state of chlorine in this reaction changes from

 - 1 to +1
 - 1 to +5
 - +1 to -1
 - +5 to -1
- What is the oxidation number of chromium in the chromate ion, CrO_4^{2-} ?
 - +6
 - +2
 - +3
 - +8
- What is the oxidation number assigned to manganese in KMnO_4 ?
 - +7
 - +2
 - +3
 - +4
- An oxidation-reduction reaction involves the
 - sharing of electrons
 - sharing of protons
 - transfer of electrons
 - transfer of protons
- During which process does an atom gain one or more electrons?
 - transmutation
 - reduction
 - oxidation
 - neutralization
- Which half-reaction correctly represents reduction?
 - $\text{Mn}^{4+} \rightarrow \text{Mn}^{3+} + \text{e}^-$
 - $\text{Mn}^{4+} \rightarrow \text{Mn}^{7+} + 3\text{e}^-$
 - $\text{Mn}^{4+} + \text{e}^- \rightarrow \text{Mn}^{3+}$
 - $\text{Mn}^{4+} + 3\text{e}^- \rightarrow \text{Mn}^{7+}$
- In a redox reaction, the total number of electrons lost is
 - less than the total number of electrons gained
 - greater than the total number of electrons gained
 - equal to the total number of electrons gained
 - equal to the total number of protons gained
- Which changes occur when Pt^{2+} is reduced?
 - The Pt^{2+} gains electrons and its oxidation number increases.
 - The Pt^{2+} gains electrons and its oxidation number decreases.
 - The Pt^{2+} loses electrons and its oxidation number increases.
 - The Pt^{2+} loses electrons and its oxidation number decreases.
- Which half-reaction equation represents the reduction of an iron(II) ion?
 - $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+} + \text{e}^-$
 - $\text{Fe}^{2+} + 2\text{e}^- \rightarrow \text{Fe}$
 - $\text{Fe}^{3+} + \text{e}^- \rightarrow \text{Fe}_{2+}$
 - $\text{Fe} \rightarrow \text{Fe}^{2+} + 2\text{e}^-$
- Which half-reaction equation represents the reduction of a potassium ion?
 - $\text{K}^+ + \text{e}^- \rightarrow \text{K}$
 - $\text{K} + \text{e}^- \rightarrow \text{K}^+$
 - $\text{K}^+ \rightarrow \text{K} + \text{e}^-$
 - $\text{K} \rightarrow \text{K}^+ + \text{e}^-$
- Which metal is more active than H_2 ?
 - Ag
 - Au
 - Cu
 - Pb

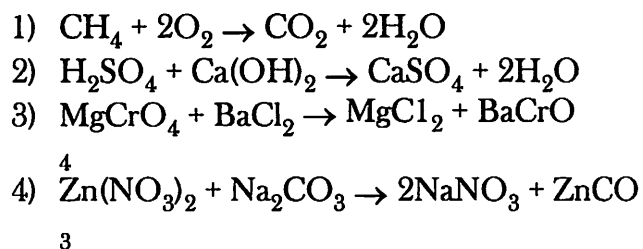
14. Given the balanced equation representing a reaction:



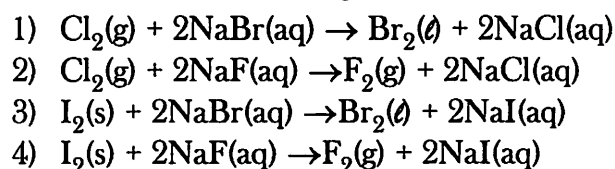
During this reaction, the oxidation number of Fe changes from

- 1) +2 to 0 as electrons are transferred
 - 2) +2 to 0 as protons are transferred
 - 3) +3 to 0 as electrons are transferred
 - 4) +3 to 0 as protons are transferred
15. Which balanced equation represents an oxidation-reduction reaction?
- 1) $\text{Ba}(\text{NO}_3)_2 + \text{Na}_2\text{SO}_4 \rightarrow \text{BaSO}_4 + 2\text{NaNO}_3$
 - 2) $\text{H}_3\text{PO}_4 + 3\text{KOH} \rightarrow \text{K}_3\text{PO}_4 + 3\text{H}_2\text{O}$
 - 3) $\text{Fe}(\text{s}) + \text{S}(\text{s}) \rightarrow \text{FeS}(\text{s})$
 - 4) $\text{NH}_3(\text{g}) + \text{HCl}(\text{g}) \rightarrow \text{NH}_4\text{Cl}(\text{s})$
16. Which balanced equation represents a redox reaction?
- 1) $\text{AgNO}_3(\text{aq}) + \text{NaCl}(\text{aq}) \rightarrow \text{AgCl}(\text{s}) + \text{NaNO}_3(\text{aq})$
 - 2) $\text{H}_2\text{CO}_3(\text{aq}) \rightarrow \text{H}_2\text{O}(\ell) + \text{CO}_2(\text{g})$
 - 3) $\text{NaOH}(\text{aq}) + \text{HCl}(\text{aq}) \rightarrow \text{NaCl}(\text{aq}) + \text{H}_2\text{O}(\ell)$
 - 4) $\text{Mg}(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{MgCl}_2(\text{aq}) + \text{H}_2(\text{g})$
17. Which balanced equation represents a redox reaction?
- 1) $\text{PCl}_5 \rightarrow \text{PCl}_3 + \text{Cl}_2$
 - 2) $\text{KOH} + \text{HCl} \rightarrow \text{KCl} + \text{H}_2\text{O}$
 - 3) $\text{LiBr} \rightarrow \text{Li}^+ + \text{Br}^-$
 - 4) $\text{Ca}^{2+} + \text{SO}_4^{2-} \rightarrow \text{CaSO}_4$
18. Why does the following reaction go to completion?
 $\text{Cu}(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{CuCl}_2(\text{aq}) + \text{H}_2(\text{g})$
- 1) water is formed
 - 2) a gas is formed
 - 3) the reaction can proceed in both directions
 - 4) the reaction is at equilibrium

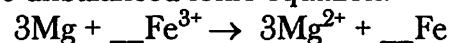
19. Which equation represents an oxidation-reduction reaction?



20. Which reaction occurs spontaneously?



21. Given the unbalanced ionic equation:



When this equation is balanced, both Fe^{3+} and Fe have a coefficient of

- 1) 1, because a total of 6 electrons is transferred
 - 2) 2, because a total of 6 electrons is transferred
 - 3) 1, because a total of 3 electrons is transferred
 - 4) 2, because a total of 3 electrons is transferred
22. Which half-reaction shows conservation of charge?
- 1) $\text{Cu} + \text{e}^- \rightarrow \text{Cu}^+$
 - 2) $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$
 - 3) $\text{Cu}^+ \rightarrow \text{Cu} + \text{e}^-$
 - 4) $\text{Cu}^{2+} \rightarrow \text{Cu} + 2\text{e}^-$
23. Which expression correctly represents a balanced reduction half-reaction?
- 1) $\text{Na}^+ + \text{e}^- \rightarrow \text{Na}$
 - 2) $\text{Na} \rightarrow \text{Na}^+ + \text{e}^-$
 - 3) $\text{Cl}_2 + 2\text{e}^- \rightarrow \text{Cl}^-$
 - 4) $2\text{Cl}^- \rightarrow \text{Cl}_2 + 2\text{e}^-$

24. Which equation shows conservation of charge?

- 1) $\text{Fe} \rightarrow \text{Fe}^{2+} + \text{e}^-$ 3) $\text{Fe} \rightarrow \text{Fe}^{2+} + 2\text{e}^-$
2) $\text{Fe} + 2\text{e}^- \rightarrow \text{Fe}^{2+}$ 4) $\text{Fe} + 2\text{e}^- \rightarrow \text{Fe}^{3+}$

25. Which statement describes where the oxidation and reduction half-reactions occur in an operating electrochemical cell?

- 1) Oxidation and reduction both occur at the anode.
2) Oxidation and reduction both occur at the cathode.
3) Oxidation occurs at the anode, and reduction occurs at the cathode.
4) Oxidation occurs at the cathode, and reduction occurs at the anode.

26. Which energy change occurs in an operating voltaic cell?

- 1) chemical to electrical
2) electrical to chemical
3) chemical to nuclear
4) nuclear to chemical

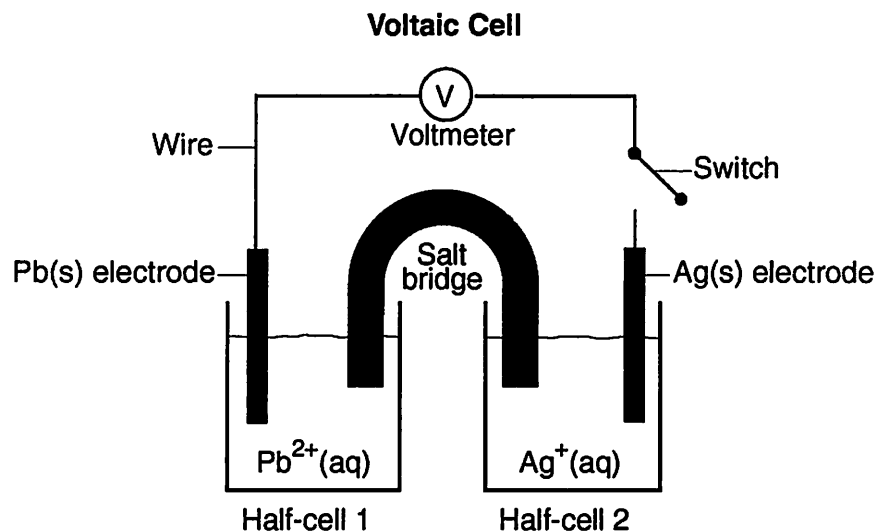
27. Which energy conversion occurs during the operation of a voltaic cell?

- 1) Chemical energy is spontaneously converted to electrical energy.
2) Chemical energy is converted to electrical energy only when an external power source is provided.
3) Electrical energy is spontaneously converted to chemical energy.
4) Electrical energy is converted to chemical energy only when an external power source is provided.

28. Which half-reaction can occur at the anode in a voltaic cell?

- 1) $\text{Ni}^{2+} + 2\text{e}^- \rightarrow \text{Ni}$ 3) $\text{Zn} \rightarrow \text{Zn}^{2+} + 2\text{e}^-$
2) $\text{Sn} + 2\text{e}^- \rightarrow \text{Sn}^{2+}$ 4) $\text{Fe}^{3+} \rightarrow \text{Fe}^{2+} + \text{e}^-$

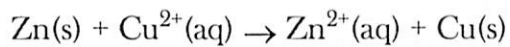
Base your answers to questions 29 through 31 on the diagram of the voltaic cell below.



29. When the switch is closed, in which half-cell does oxidation occur?
30. When the switch is closed, state the direction that electrons will flow through the wire.
31. *Based on the given equation*, write the balanced half-reaction that occurs in half-cell 1.

-
32. Reduction occurs at the cathode in
- 1) electrolytic cells, only
 - 2) voltaic cells, only
 - 3) both electrolytic cells and voltaic cells
 - 4) neither electrolytic cells nor voltaic cells
33. Which metal can be produced only by the electrolysis of its fused salt?
- | | |
|-------|-------|
| 1) Ag | 3) Pb |
| 2) Zn | 4) K |

34. Given the balanced ionic equation representing the reaction in an operating voltaic cell:



The flow of electrons through the external circuit in this cell is from the

- 1) Cu anode to the Zn cathode
 - 2) Cu cathode to the Zn anode
 - 3) Zn anode to the Cu cathode
 - 4) Zn cathode to the Cu anode
35. A student collects the materials and equipment below to construct a voltaic cell:

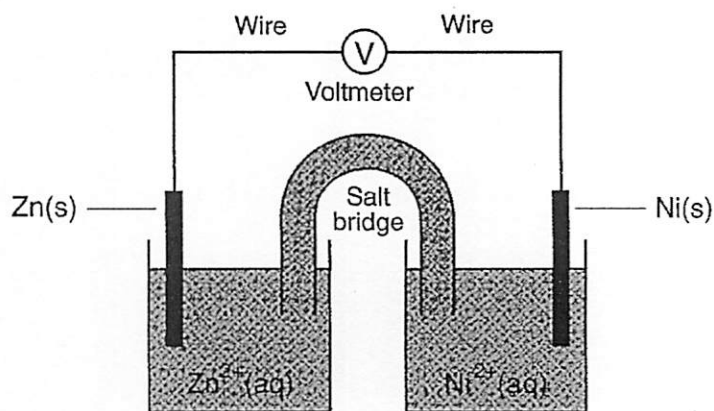
- two 250-mL beakers
- wire and a switch
- one strip of magnesium
- one strip of copper
- 125 mL of 0.20 M $\text{Mg}(\text{NO}_3)_2(\text{aq})$
- 125 mL of 0.20 M $\text{Cu}(\text{NO}_3)_2(\text{aq})$

Which additional item is required for the construction of the voltaic cell?

- 1) an anode
 - 2) a battery
 - 3) a cathode
 - 4) a salt bridge
36. Which energy conversion occurs in an operating electrolytic cell?
- 1) chemical energy to electrical energy
 - 2) electrical energy to chemical energy
 - 3) nuclear energy to thermal energy
 - 4) thermal energy to nuclear energy

37. Which statement describes one characteristic of an operating electrolytic cell?
- 1) It produces electrical energy.
 - 2) It requires an external energy source.
 - 3) It uses radioactive nuclides.
 - 4) It undergoes a spontaneous redox reaction.

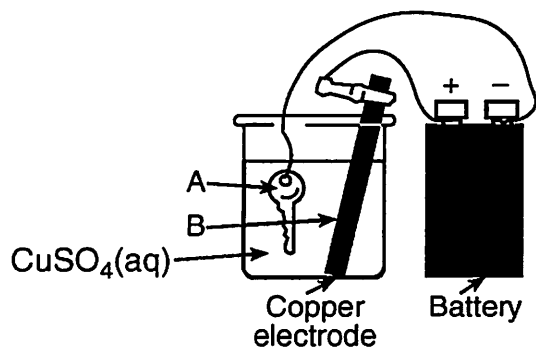
38. The diagram below represents an operating electrochemical cell and the balanced ionic equation for the reaction occurring in the cell.



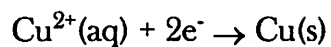
Which statement identifies the part of the cell that conducts electrons and describes the direction of electron flow as the cell operates?

- 1) Electrons flow through the salt bridge from the Ni(s) to the Zn(s).
 - 2) Electrons flow through the salt bridge from the Zn(s) to the Ni(s).
 - 3) Electrons flow through the wire from the Ni(s) to the Zn(s).
 - 4) Electrons flow through the wire from the Zn(s) to the Ni(s).
39. Metals from which groups are obtained by the reduction of their fused salts?
- 1) Group 1 and Group 2
 - 2) Group 1 and Group 12
 - 3) Group 2 and Group 11
 - 4) Group 11 and Group 12

40. The diagram below shows a key being plated with copper in an electrolytic cell



Given the reduction reaction for this cell:

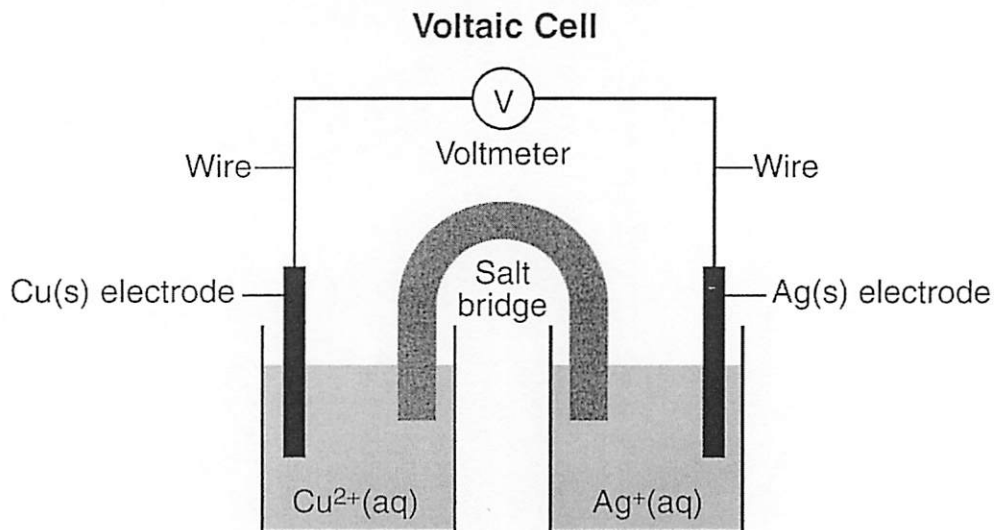


This reduction occurs at

- 1) *A*, which is the anode
- 2) *A*, which is the cathode
- 3) *B*, which is the anode
- 4) *B*, which is the cathode

Base your answers to questions 41 and 42 on the information below.

The diagram and balanced ionic equation below represent a voltaic cell with copper and silver electrodes and the reaction that occurs when the cell is operating.



41. State the purpose of the salt bridge in this voltaic cell.
42. Describe the direction of electron flow in the external circuit in this operating cell.

43. Base your answer to the following question on the information below

The unbalanced equation below represents the decomposition of potassium chlorate.



Balance the equation *below*, using the smallest whole-number coefficients.



44. Explain, in terms of activity, why $\text{HCl}(\text{aq})$ reacts with $\text{Zn}(\text{s})$, but $\text{HCl}(\text{aq})$ does *not* react with $\text{Cu}(\text{s})$.

45. Base your answer to the following question on the information below.

A student performed a laboratory activity to observe the reaction between aluminum foil and an aqueous copper(II) chloride solution. The reaction is represented by the balanced equation below.



The procedures and corresponding observations for the activities are given below.

| Procedure | Observation |
|--|--|
| In a beaker, completely dissolve 5.00 g of CuCl_2 in 80.0 mL of H_2O . | <ul style="list-style-type: none">• The solution is blue green. |
| Cut 1.5 g of $\text{Al}(s)$ foil into small pieces. Add all the foil to the mixture in the beaker. Stir the contents for 1 minute. | <ul style="list-style-type: none">• The surface of $\text{Al}(s)$ foil appears partially black.• The beaker feels warm to the touch. |
| Observe the beaker and contents after 10 minutes. | <ul style="list-style-type: none">• The liquid in the beaker appears colorless.• A reddish-brown solid is seen at the bottom of the beaker.• Some pieces of $\text{Al}(s)$ with a partially black coating remain in the beaker. |

State *one* observation that indicates Cu^{2+} ions became Cu atoms.