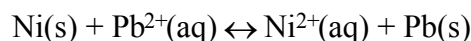


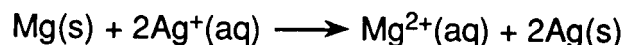
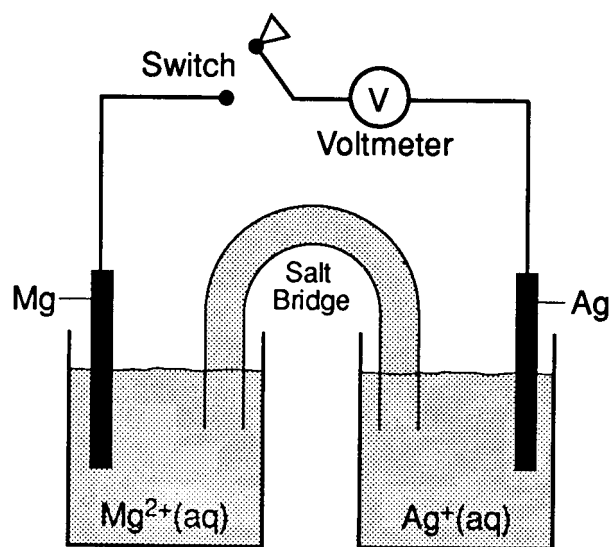
- Which ionic equation represents a spontaneous reaction that can occur in a voltaic cell?
  - $\text{Cu(s)} + \text{Zn(s)} \rightarrow \text{Cu}^{2+}(\text{aq}) + \text{Zn}^{2+}(\text{aq})$
  - $\text{Cu(s)} + \text{Zn}^{2+}(\text{aq}) \rightarrow \text{Cu}^{2+}(\text{aq}) + \text{Zn(s)}$
  - $\text{Cu}^{2+}(\text{aq}) + \text{Zn(s)} \rightarrow \text{Cu(s)} + \text{Zn}^{2+}(\text{aq})$
  - $\text{Cu}^{2+}(\text{aq}) + \text{Zn}^{2+}(\text{aq}) \rightarrow \text{Cu(s)} + \text{Zn(s)}$
- In an operating voltaic cell, reduction occurs
  - at the anode
  - at the cathode
  - in the salt bridge
  - in the wire
- During the operation of a voltaic cell, the cell produces
  - electrical energy spontaneously
  - chemical energy spontaneously
  - electrical energy nonspontaneously
  - chemical energy nonspontaneously
- Which energy change occurs in an operating voltaic cell?
  - chemical to electrical
  - electrical to chemical
  - chemical to nuclear
  - nuclear to chemical
- Which energy conversion occurs in a voltaic cell?
  - chemical energy to electrical energy
  - chemical energy to nuclear energy
  - electrical energy to chemical energy
  - nuclear energy to electrical energy
- Which process occurs in an operating electrochemical cell?
  - a reduction reaction, only
  - an oxidation reaction, only
  - a chemical reaction produced by an electric current
  - a chemical reaction that produces an electric current

- Given the redox reaction in an electrochemical cell:



A salt bridge is used to connect

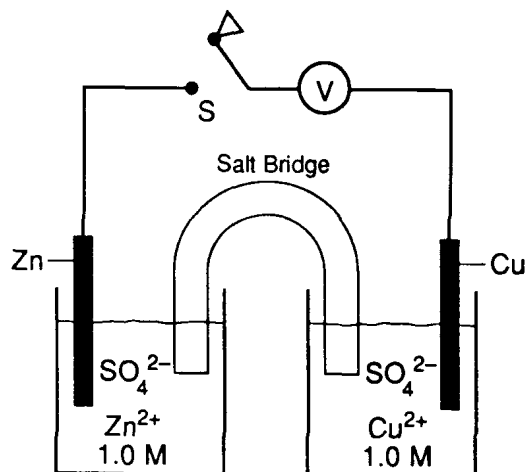
- $\text{Ni(s)}$  and  $\text{Pb(s)}$
  - $\text{Pb}^{2+}(\text{aq})$  and  $\text{Ni}^{2+}(\text{aq})$
  - $\text{Ni(s)}$  and  $\text{Ni}^{2+}(\text{aq})$
  - $\text{Pb}^{2+}(\text{aq})$  and  $\text{Pb(s)}$
- Base your answer to the following question on the equation and diagram below represent an electrochemical cell at 298 K and 1 atmosphere.



Which species is oxidized when the switch is closed?

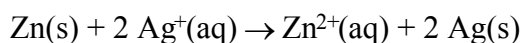
- $\text{Mg(s)}$
  - $\text{Mg}^{2+}(\text{aq})$
  - $\text{Ag(s)}$
  - $\text{Ag}^{+}(\text{aq})$
- A chemical cell differs from an electrolytic cell because in a chemical cell there is
    - a positive and negative electrode
    - an anode and a cathode
    - a redox reaction that produces an electric current
    - an electric current that causes a redox reaction

10. Base your answer to the following question on the diagram below which represents a chemical cell at 298 K and 1 atmosphere.



Which species represents the cathode?

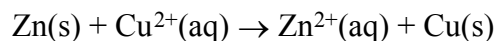
- A) Zn    B)  $\text{Zn}^{2+}$     C) Cu    D)  $\text{Cu}^{2+}$
11. A standard zinc half-cell is connected to a standard copper half cell by means of a wire and a salt bridge. Which electronic equation represents the oxidation reaction that takes place?
- A)  $\text{Cu}^0 - 2e^- \rightarrow \text{Cu}^{2+}$   
 B)  $\text{Cu}^{2+} + 2e^- \rightarrow \text{Cu}^0$   
 C)  $\text{Zn}^0 - 2e^- \rightarrow \text{Zn}^{2+}$   
 D)  $\text{Zn}^{2+} + 2e^- \rightarrow \text{Zn}^0$
12. Given the overall cell reaction:



Which will occur as the cell operates?

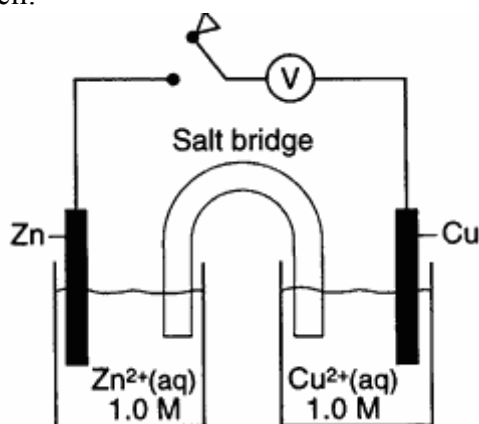
- A) The amount of  $\text{Zn(s)}$  will increase.  
 B) The amount of  $\text{Ag(s)}$  will decrease.  
 C) The concentration of  $\text{Zn}^{2+}(\text{aq})$  will increase.  
 D) The concentration of  $\text{Ag}^+(\text{aq})$  will increase.

13. 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

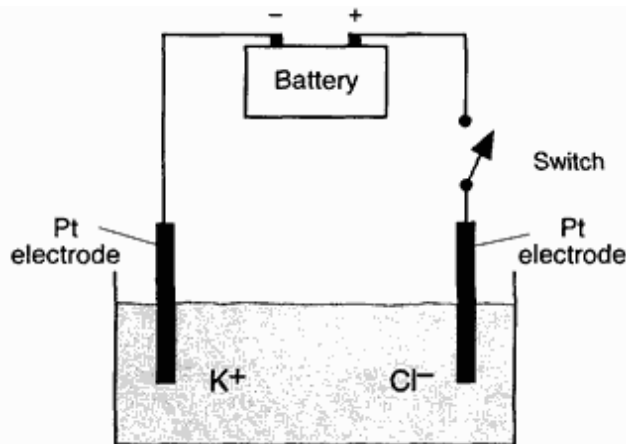
- A) Cu anode to the Zn cathode  
 B) Cu cathode to the Zn anode  
 C) Zn anode to the Cu cathode  
 D) Zn cathode to the Cu anode
14. The diagram below represents an electrochemical cell.



What occurs when the switch is closed?

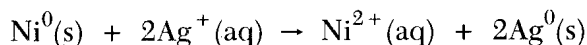
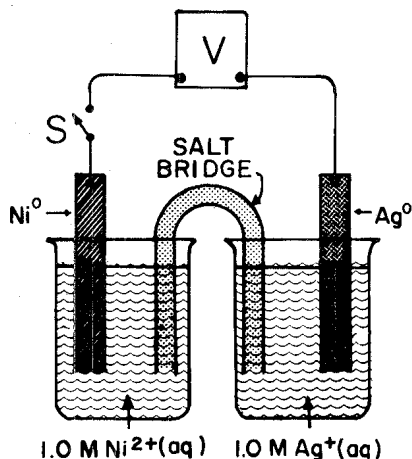
- A) Zn is reduced.  
 B) Cu is oxidized.  
 C) Electrons flow from Cu to Zn.  
 D) Electrons flow from Zn to Cu.

15. The diagram below shows the electrolysis of fused KCl.



What occurs when the switch is closed?

- A) Positive ions migrate toward the anode, where they lose electrons.  
 B) Positive ions migrate toward the anode, where they gain electrons.  
 C) Positive ions migrate toward the cathode, where they lose electrons.  
 D) Positive ions migrate toward the cathode, where they gain electrons.
16. Base your answer to the following question on the diagram of the chemical cell at 298 K and on the equation below.



In an electrolytic cell,  $\text{Ag}^+$  ions will

- A) migrate to the positive electrode  
 B) migrate to the negative electrode  
 C) be reduced at the positive electrode  
 D) be oxidized at the negative electrode
17. Which metal is more active than  $\text{H}_2$ ?  
 A) Ag B) Au C) Cu D) Pb
18. Which reaction occurs spontaneously?  
 A)  $\text{Cl}_2(\text{g}) + 2\text{NaBr}(\text{aq}) \rightarrow \text{Br}_2(\ell) + 2\text{NaCl}(\text{aq})$   
 B)  $\text{Cl}_2(\text{g}) + 2\text{NaF}(\text{aq}) \rightarrow \text{F}_2(\text{g}) + 2\text{NaCl}(\text{aq})$   
 C)  $\text{I}_2(\text{s}) + 2\text{NaBr}(\text{aq}) \rightarrow \text{Br}_2(\ell) + 2\text{NaI}(\text{aq})$   
 D)  $\text{I}_2(\text{s}) + 2\text{NaF}(\text{aq}) \rightarrow \text{F}_2(\text{g}) + 2\text{NaI}(\text{aq})$
19. Which metal reacts spontaneously with a solution containing zinc ions?  
 A) magnesium B) nickel  
 C) copper D) silver
20. According to Reference Table J, which metal will react with  $\text{Zn}^{2+}$  but will *not* react with  $\text{Mg}^{2+}$ ?  
 A) Al(s) B) Cu(s) C) Ni(s) D) Ba(s)
21. According to Reference Table J, which species is most easily reduced?  
 A)  $\text{F}_2(\text{g})$  B)  $\text{F}^-$  C)  $\text{Li}^+$  D) Li(s)
22. Referring to Reference Table J, which reaction will not occur under standard conditions?  
 A)  $\text{Sn}(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{SnCl}_2(\text{aq}) + \text{H}_2(\text{g})$   
 B)  $\text{Cu}(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{CuCl}_2(\text{aq}) + \text{H}_2(\text{g})$   
 C)  $\text{Ba}(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{BaCl}_2(\text{aq}) + \text{H}_2(\text{g})$   
 D)  $\text{Mg}(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{MgCl}_2(\text{aq}) + \text{H}_2(\text{g})$
23. According to Reference Table J, which redox reaction occurs spontaneously?  
 A)  $\text{Cu}(\text{s}) + 2\text{H}^+ \rightarrow \text{Cu}^{2+} + \text{H}_2(\text{g})$   
 B)  $\text{Mg}(\text{s}) + 2\text{H}^+ \rightarrow \text{Mg}^{2+} + \text{H}_2(\text{g})$   
 C)  $2\text{Ag}(\text{s}) + 2\text{H}^+ \rightarrow 2\text{Ag} + \text{H}_2(\text{g})$   
 D)  $2\text{Ag}(\text{s}) + 2\text{H}^+ \rightarrow 2\text{Ag}^{2+} + \text{H}_2(\text{g})$
24. Based on the Activity Series, which ion will react spontaneously with Co(s)?  
 A)  $\text{Zn}^{2+}$  B)  $\text{Al}^{3+}$  C)  $\text{Li}^+$  D)  $\text{Ag}^+$
25. Based on Reference Table J, which of the following elements will replace Pb from  $\text{Pb}(\text{NO}_3)_2(\text{aq})$ ?  
 A) Mg(s) B) Au(s)  
 C) Cu(s) D) Ag(s)
26. According to Reference Table J, which element will react spontaneously with  $\text{Al}^{3+}$  at 298 K?  
 A) Cu B) Au C) Li D) Ni

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27. According to reference Table J, which reaction will occur spontaneously?

- A)  $\text{Co}^{2+} + \text{Cu(s)} \rightarrow \text{Co(s)} + \text{Cu}^{2+}$
- B)  $\text{Ag}^+ + \text{Cu(s)} \rightarrow \text{Ag(s)} + \text{Cu}^+$
- C)  $\text{Fe}^{2+} + \text{Hg(l)} \rightarrow \text{Fe(s)} + \text{Hg}^{2+}$
- D)  $\text{Mg}^{2+} + \text{Sn}^{2+} \rightarrow \text{Mg(s)} + \text{Sn}^{4+}$

28. According to Reference Table J, which metal will react spontaneously with  $\text{H}^+$ ?

- A) Au    B) Ag    C) Cr    D) Cu

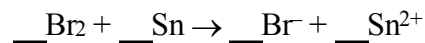
29. Which will oxidize  $\text{Zn(s)}$  to  $\text{Zn}^{2+}$ , but will *not* oxidize  $\text{Pb(s)}$  to  $\text{Pb}^{2+}$ ?

- A)  $\text{Al}^{3+}$     B)  $\text{Au}^{3+}$     C)  $\text{Co}^{2+}$     D)  $\text{Mg}^{2+}$

30. According to Reference Table J, which halogen will react spontaneously with  $\text{Au(s)}$  to produce  $\text{Au}^{3+}$ ?

- A)  $\text{Br}_2$     B)  $\text{F}_2$     C)  $\text{I}_2$     D)  $\text{Cl}_2$

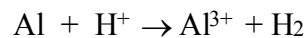
31. Given the unbalanced equation:



When the equation is correctly balanced using the smallest whole-number coefficients, the coefficient of  $\text{Br}^-$  is

- A) 1    B) 2    C) 3    D) 4

32. Given the unbalanced equation which represents aluminum metal reacting with an acid:



What is the total number of moles of electrons lost by 1 mole of aluminum?

- A) 6    B) 2    C) 3    D) 13
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