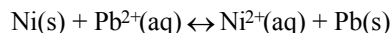1) A voltaic cell spontaneously converts

   A) electrical energy to chemical energy
   B) chemical energy to electrical energy
   C) electrical energy to nuclear energy
   D) nuclear energy to electrical energy

2) Given the redox reaction in an electrochemical cell:

$$Ni(s) + Pb^{2+}(aq) \leftrightarrow Ni^{2+}(aq) + Pb(s)$$

A salt bridge is used to connect

   A) Ni(s) and Pb(s)   B) $Pb^{2+}(aq)$ and $Ni^{2+}(aq)$
   C) Ni(s) and $Ni^{2+}(aq)$ D) $Pb^{2+}(aq)$ and Pb(s)

3) Which statement is true for any electrochemical cell?

   A) Oxidation occurs at the anode, only.
   B) Reduction occurs at the anode, only.
   C) Oxidation occurs at both the anode and the cathode.
   D) Reduction occurs at both the anode and the cathode.

4) In an oxidation-reduction reaction, the number of electrons lost is

   A) equal to the number of electrons gained
   B) equal to the number of protons gained
   C) less than the number of electrons gained
   D) less than the number of protons gained

5) Base your answer to the following question on the equation and diagram below represent an electrochemical cell at 298 K and 1 atmosphere.

$$Mg(s) + 2Ag^+(aq) \longrightarrow Mg^{2+}(aq) + 2Ag(s)$$
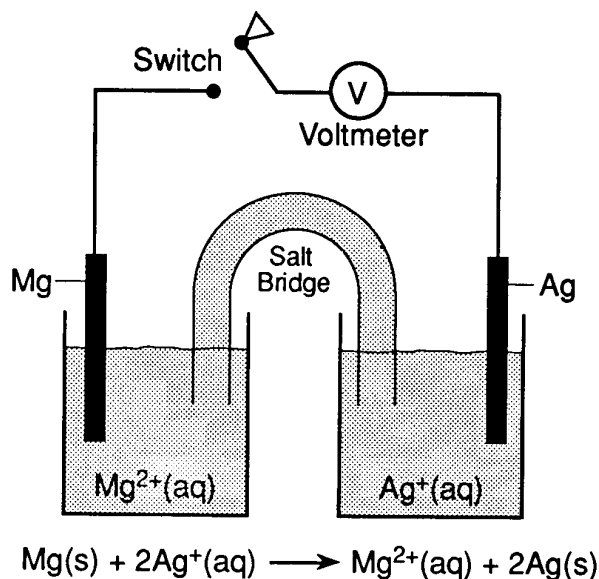
Which species is oxidized when the switch is closed?

   A) Mg(s)   B) Mg^{2+} (aq)
   C) Ag(s)   D) $Ag^+(aq)$

6) Which equation shows conservation of charge?

   A) $Fe \rightarrow Fe^{2+} + e^-$ B) $Fe + 2e^- \rightarrow Fe^{2+}$
   C) $Fe \rightarrow Fe^{2+} + 2e^-$ D) $Fe + 2e^- \rightarrow Fe^{3+}$

7) The redox reaction in a battery during discharge can best be described as

   A) non-spontaneous and occurring in a chemical cell
   B) spontaneous and occurring in a chemical cell
   C) non-spontaneous and occurring in an electrolytic cell
   D) spontaneous and occurring in an electrolytic cell

8) Given the overall cell reaction:

$$Zn(s) + 2\ Ag^+(aq) \rightarrow Zn^{2+}(aq) + 2\ Ag(s)$$
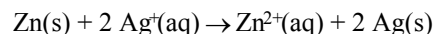
Which will occur as the cell operates?

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

9) Base your answer to the following question on the diagram of the chemical cell at 298 K and on the equation below.

$$Ni^0(s) + 2Ag^+(aq) \rightarrow Ni^{2+}(aq) + 2Ag^0(s)$$
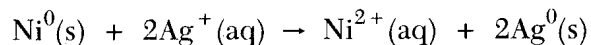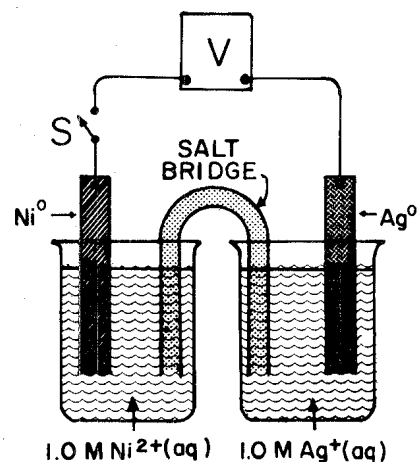
In the given reaction, the Ag^+ ions

   A) gain electrons   B) lose electrons
   C) gain protons   D) lose protons

10) 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 $Mg(NO_3)_2(aq)$
   • 125 mL of 0.20 M $Cu(NO_3)_2(aq)$

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

   A) an anode   B) a battery
   C) a cathode   D) a salt bridge

Base your answers to questions **11** and **12** on the diagram below which represents a chemical cell at 298 K and 1 atmosphere.
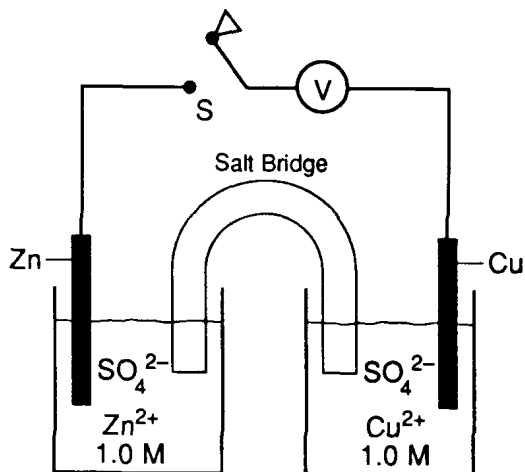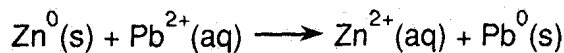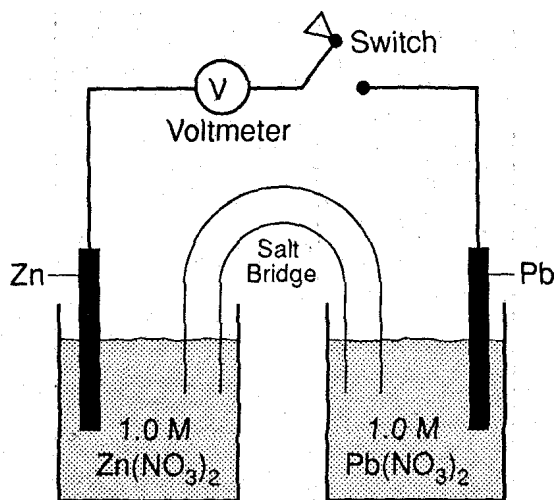

11) Which species represents the cathode?

   A) Zn   B) Zn^{2+} C) Cu   D) Cu^{2+}

12) When switch S is closed, electrons in the external circuit will flow from

   A) Zn to Zn^{2+} B) Zn to Cu
   C) Cu to Zn^{2+} D) Cu to Zn

13) Base your answer to the following question on the diagram of the chemical cell shown below. The reaction occurs at 1 atmosphere and 298 K.


$$Zn^0(s) + Pb^{2+}(aq) \longrightarrow Zn^{2+}(aq) + Pb^0(s)$$

When the switch is closed, what occurs?

A) Pb is oxidized and electrons flow to the Zn electrode.
B) Pb is reduced and electrons flow to the Zn electrode.
C) Zn is oxidized and electrons flow to the Pb electrode.
D) Zn is reduced and electrons flow to the Pb electrode.

14) Which component of an electrochemical cell is correctly paired with its function?

A) external conductor – allows the solutions to mix
B) external conductor – permits the migration of ions
C) salt bridge – allows the solutions to mix
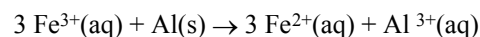D) salt bridge – permits the migration of ions

15) The diagram below represents an electrochemical cell.
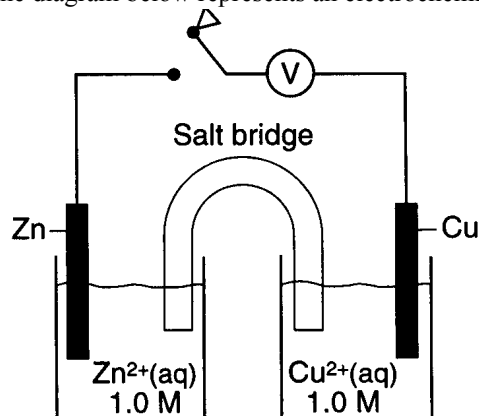
What occurs when the switch is closed?

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

16) Given the balanced equation:

$$3\ Fe^{3+}(aq) + Al(s) \rightarrow 3\ Fe^{2+}(aq) + Al^{3+}(aq)$$

What is the total number of moles of electrons lost by 2 moles of Al(s)?

A) 1 mole   B) 6 moles
C) 3 moles   D) 9 moles

17) Which ionic equation is balanced?

A) $Fe^{3+} + Al \rightarrow Fe^{2+} + Al^{3+}$
B) $Fe^{3+} + 3Al \rightarrow Fe^{2+} + 3Al^{3+}$
C) $3Fe^{3+} + Al \rightarrow 3Fe^{2+} + Al^{3+}$
D) $3Fe^{3+} + Al \rightarrow Fe^{2+} + 3Al^{3+}$